# WATERFOWL (ANATIDAE) UTILIZATION OF IMPOUNDMENTS IN A NORTH-CENTRAL OKLAHOMA WATERSHED


BY

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IN A NORTH-CENTRAL OKLAHOMA WATERSHED

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TABLE OF CONTENTS

| Chapter | Page |
| --- | --- |

LIST OF TABLES

| Table | | Page |
|---|---|---|

## LIST OF FIGURES

Figure Page

# CHAPTER I

# INTRODUCTION

For 200 years the trend in water management in the United States was the reduction of surface waters and the desiccation of moist sites. However, within the present century the trend has been to hold surface runoff for many uses and a variety of situations. Small storage impoundments, built by private landowners, constitutes one of the more important and useful types of water management (Giles et al. 1970). Within the past 25 years, landowners in the United States have constructed more than 2 million tanks and ponds having a combined surface area approaching that of Lake Ontario (Gambell 1966). Many of these structures are components of authorized flood prevention watersheds and Public Law 83-566 watershed projects. The building of impoundments is encouraged by various government assistance programs by providing technical and financial aid. Edminster (1965) predicted an additional increase of 1.3 million ponds by 1980.

Many artificial ponds and watershed structures, built for other uses, are or can be valuable to wildlife. Their utility is governed by many factors, including geographical location, water quality, stability of water level, area and depth, physical characteristics and fertility of the soil, nature of the shoreline and adjacent upland, type of vegetation, and extent and type of human and other disturbances (Stewart and Kantrud 1969; Trauger 1967; and Barstow 1957).

During the past 20 years Oklahoma has had a substantial increase in its water resources. In 1975, reservoirs, farm ponds, watershed structures, and lakes provided approximately 190,000 surface ha. of water within the state (Jimmy Hill, Okla. Soil Conservation Service, personal communication). The immediate socio-economic benefits from these structures include flood control, recreation, irrigation, municipal water supplies and livestock watering. One indirect benefit is the creation of waterfowl habitat.

Although various investigators (Trauger 1967; Bennett 1938; Evans et al. 1952; Smith 1953; Harris 1954; Farmes 1956; Stewart and Kantrud 1971; and others) have studied waterfowl brood preference in relation to pothole or reservoir size, water depth and amount of aquatic vegetation, very little information is available on the habitat preferences of migrating waterfowl during their migration and wintering periods. These investigations support the concept that the use of wetlands may be dependent upon size, water depth and vegetation. Keith (1961) reports that water chemistry influences the use of prairie pothole and western production habitat areas. Ecological investigations of wetlands in North Dakota indicate that the use of prairie ponds by breeding waterfowl is influenced by water permanence, depth, chemistry, and by land use (Stewart and Kantrud 1969). While these factors are complex and interrelated, they are reflected in differences in life forms, cover interspersion, species composition, and species dominance of aquatic vegetation. This situation may also be true for wetlands in other areas, including north-central Oklahoma.

Previous studies in Oklahoma are limited in their definitions of habitat selection patterns by migratory waterfowl. Barstow (1957) studied the availability of waterfowl foods and waterfowl use on a series of 21 clear and 23 turbid farm ponds in north-central Oklahoma. He found that waterfowl prefer clear ponds to turbid ones, and turbidity is indicative of a lack of aquatic vegetation. Hancock (1951) reported on food habits of migratory waterfowl passing through Payne County, Oklahoma. Hancock's work demonstrated the importance of Lakes Blackwell (1300 ha.) and Boomer (105 ha.) as feeding areas for migratory waterfowl. Metzen (1966) studied the relationships that turbidity, aquatic vegetation, disturbance and pond size have to waterfowl use of ponds in the Stillwater, Oklahoma area. His results indicated that waterfowl utilize impoundments that contain aquatic vegetation, are clear, and are a considerable distance from human disturbance. Metzen also reported on a daily pattern of waterfowl movements. Waterfowl rested at night on Lakes Blackwell and Boomer and moved out to feed in the morning on small farm ponds, returning to rest on the two large impoundments by evening. Copelin (1962) reported substantial waterfowl use of SCS flood prevention reservoirs in western Oklahoma.

The present study examined waterfowl and impoundments in a north-central Oklahoma watershed. Information obtained in this study of waterfowl numbers, distribution, and criteria for their use of impoundments in the Stillwater Creek Watershed (SCW) are presented. Specific objectives of this study were: (1) to determine the number and species of waterfowl that utilize the various impoundment types during each season (fall, winter, and spring), (2) to determine what type of impoundments are preferred by waterfowl during each season, and (3) to identify characteristics (e.g., physical shape and size, water quality, aquatic vegetation, and surrounding land activity) that are important in determining impoundment preference.

Conclusions of this study are intended to aid waterfowl management by: (1) supporting the hypothesis that habitat selection by waterfowl is due to habitat "quality" - i.e., "good" quality preferred over "poor" quality - rather than a random selection fashion, (2) providing useful information to wildlife managers responsible for waterfowl management in an area of small, artificial impoundments, (3) documenting the use of Soil Conservation Service (SCS) impoundments thereby providing incentives for the inclusion of waterfowl management plans in the SCS Watershed Program, and (4) documenting waterfowl use of impoundments in an area considered by the U.S. Fish and Wildlife Service to be of "marginal" waterfowl value.

# CHAPTER II

# DESCRIPTION OF THE STUDY AREA

## Location

Stillwater Creek Watershed, with an area of 71,719 ha. (177,216 acres) is located in north-central Oklahoma. Stillwater, the county seat of Payne County, with a population of approximately 30,000 (1970 census), is located near the center of the watershed (latitude $36^{o}$ 07', longitude $90^{o}$ 05') and is served by two major routes; U.S. 177 (north-south) and State route 51 (east-west).

The distribution of land within the watershed is as follows: 53,581 ha. in Payne County, 17,742 ha. in Noble County, and 396 ha. in Logan County. Stillwater Creek rises 6.4 km. north of Orlando, Oklahoma, and flows in a southeasterly direction for 48 km. where it joins the Cimarron River near Ripley, Oklahoma. The watershed has an average width of 11 km. on the north side of Stillwater Creek and 5 km. on the south side.

Numerous small creeks draining agricultural and woodland areas flow into Stillwater Creek. A history of flooding in the watershed prompted local sponsors, under provisions of the Watershed Protection and Flood Prevention Program (Public Law 83-566), to support the construction of upstream flood prevention structures. Twenty of the proposed 56 structures, including Lake McMurtry and Ham's Lake, had been constructed by September of 1972. Lake Carl Blackwell (Fig. 1) and Boomer Lake were constructed prior to PL-566 and are significant water supply, flood control and recreational features of the watershed.

The topography of the watershed is characterized by slightly rolling hills, fields, and pastures with numerous small streams and wooded areas. The surface elevation grades upward from a low of about 244 m. above sea level near the confluence of the Cimarron River and Stillwater Creek to a high of over 365 m. just west of Lake Carl Blackwell. The numerous creeks and streams which dissect the watershed have cut the surface to depths of over 3 m. below the surrounding elevation.

## Physiography

### Geology and Soils

The watershed is located in a major physiographic and land resource area known as the Reddish Prairies of Permian origin and genesis (Gray and Galloway 1959). The Reddish Prairie is an area of smooth to rolling lands dominated by the red sedimentary rocks of the "Red Beds" formation. At the time of settlement, tall bunch grasses occupied the loamy soils while middle height grasses occupied the clay beds. The area is characteristic of a mixed prairie occupying a continuous band from north to south across Oklahoma in the center of the state (Fig. 2). The east boundary diffuses with the Cross Timbers Land Resource Area which occurs in the southeastern portion of the watershed and in a band running north and southeast of Lake Carl Blackwell.

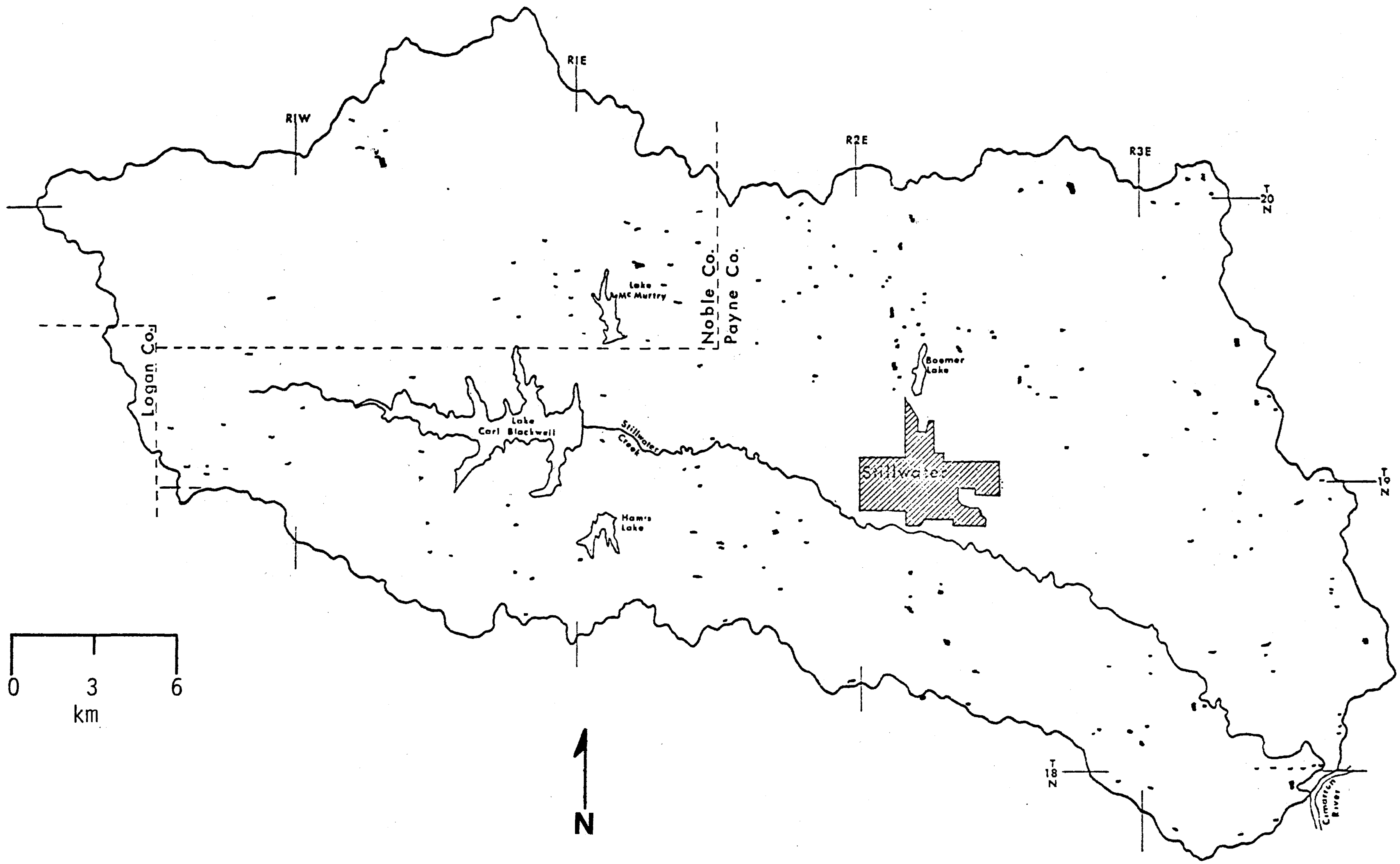


Fig. 1. Stillwater Creek Watershed, north-central Oklahoma, showing impoundments > 1 ha. in surface acreage (density slice on band 7, scene no. E-1508-16380-7 of LANDSAT-1, December 13, 1973)

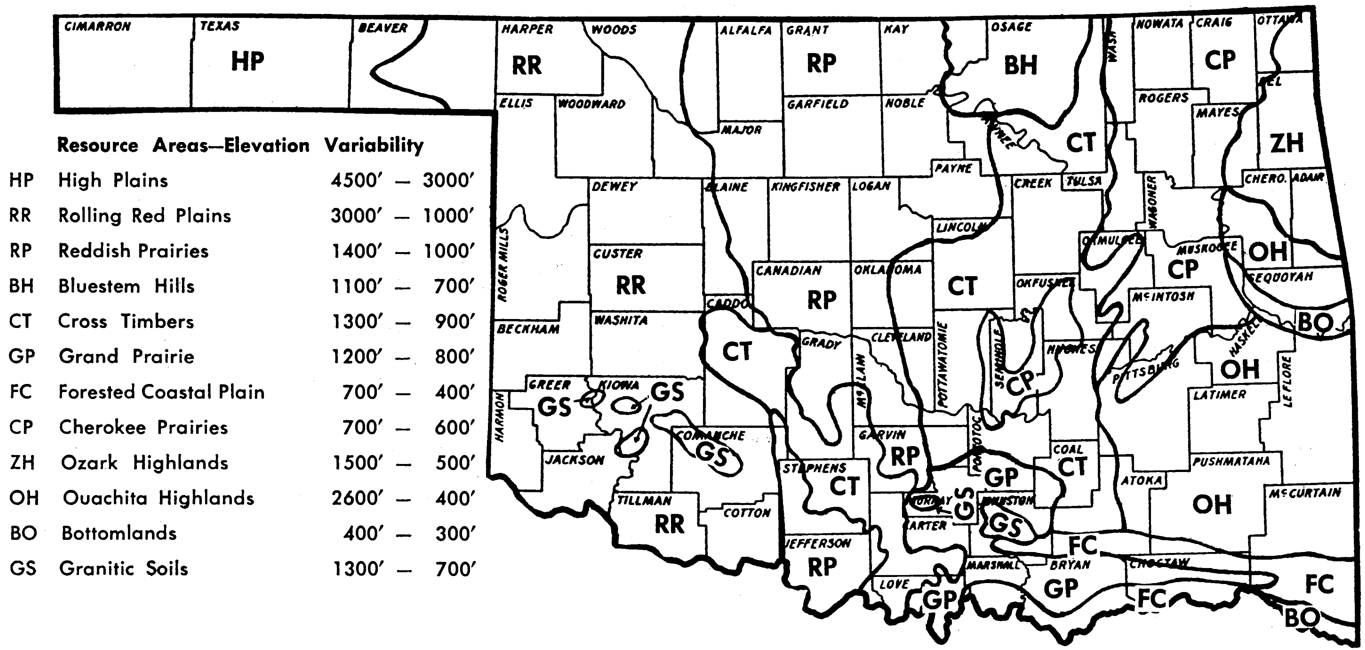


Fig. 2. Land resource areas - elevation variability of Oklahoma (Gray and Galloway 1959)

Certain soils and landscapes are adapted to cropland-pasture combinations, while others are better adapted to extensive range and forestry use. Oklahoma's Reddish Prairies, particularly in the north-central portion of the state (Fig. 2) are well adapted to cropland-pasture combinations. This type of agricultural development has resulted in a proliferation of small farm ponds for livestock watering and SCS watershed structures for erosion control (Jim Hill, Okla. SCS personal communication) in north-central Oklahoma.

The chief soils in the Reddish Prairie are of the Southern Brunizem Great Soil Group, or geographical associates of those soils (Gray and Galloway 1959). They have loamy surface soils 20 to 30 cm. thick and reddish loamy to clayey subsoils. They vary considerably in nutrient content, from high to low in phosphate and from moderate to low in nitrogen. Within the watershed are three soil associations: the Renfrow-Zaneis-Vernon Association (RZV) occurring in 85 percent of the watershed; the Darnell-Stephenville Association (DS) occurring 12 percent; and the Dougherty-Teller-Yahola Association (DTY) occurring in only 2 percent of the watershed. Zaneis are brown loam soils with granular, reddish, heavy clay loam subsoils. Under acceptable grazing conditions, surface runoff from this soil type will not usually result in turbid (due to collodial clay particles) impoundments. However, overgrazing causes the surface soils to erode, leaving the clayey subsoils which continue to erode into nearby impoundments, thereby creating turbid water conditions. Both conditions are evident in Stillwater Creek Watershed. Both the DS and DTY Soil Associations are considered part of the Cross Timbers Land Resource Areas.

Climate

Climate is as much a habitat factor to migratory waterfowl as are permanent geologic features (Lawrence 1964). The fall and spring movements of waterfowl in SCW are influenced, to some degree, by local climatic conditions. These same conditions also affect the habitat. For example, precipitation and evaporation affects the water level of an impoundment which in turn alters shoreline vegetation, turbidity, macroinvertebrate abundance, and so forth. Because climate may significantly affect waterfowl movements, a discussion of local climatological factors in SCW is presented.

The prevailing climate is temperate but of continental orgin with pronounced seasonal variations in both temperature and precipitation (U.S. Dept. Commerce 1968). Greatest weather changes occur when the warm, moist air prevailing from the Gulf Coast is met by cool, drier air arriving from Pacific and Arctic regions. Spring is the season of the most changeable conditions, heaviest rains and the greatest number of severe storms. Summers are characterized as being long and quite warm; having a high percentage of available sunshine; and with occasional showers, thunderstorms and moderate winds. Fall provides a long gradual transition from the summer extremes to the cold spells of winter. A secondary maximum of rainfall occurs early in fall and is followed by a high percent of sunshine, cool nights, and rainfalls of long duration. Winters are generally mild and short with brief periods of low temperatures and occasional snow cover.

Annual precipitation at Stillwater has averaged from around 43 cm. to 57 cm. Eight out of ten years will receive between 56 and 114 cm.

of moisture. Seasonal distribution of moisture averages 11 percent in winter, 29 percent in spring, 35 percent in summer, and 25 percent in the fall. Daily totals of 1.3 cm. or more occur on an average of 18 days per year and totals of 2.5 cm. or more, 9 days per year. Heavy daily rains of 10 to 18 cm. occur very infrequently.

Snowfall accounts for 16 percent of the moisture received during winter and has occurred from October through April. Average annual snowfall is 30 cm. The average freeze-free season in the watershed ranges from 205 to 211 days.

The percent of possible sunshine received at Stillwater averages from 60 percent in January to 76 percent in August with the annual average of 67 percent. An average year has 140 clear days, 97 partly cloudy days, and 128 cloudy days. The hourly wind speed averages 18 kph for a year and ranges from 16 kph in August to 21 kph in March. Southerly winds prevail except during January and February when northerly winds predominate. Annual lake evaporation averages 145 cm. with 70 percent of this amount occurring from May through October.

## Vegetation

Much of the original vegetation of the watershed has been altered by man in recent years. Overgrazing, burning, land clearing, erosion, and cultivation have left few native climax areas. Some native vegetation remains, but it is found in relatively small stands. The watershed is located in the Cross Timbers/Mixed Grass vegetational types (Gray and Galloway 1959) which forms an ecotone between woodlands and grasslands, characteristic of central Oklahoma (Fig. 3). The mixed grass portion of the watershed is dominated by little and big

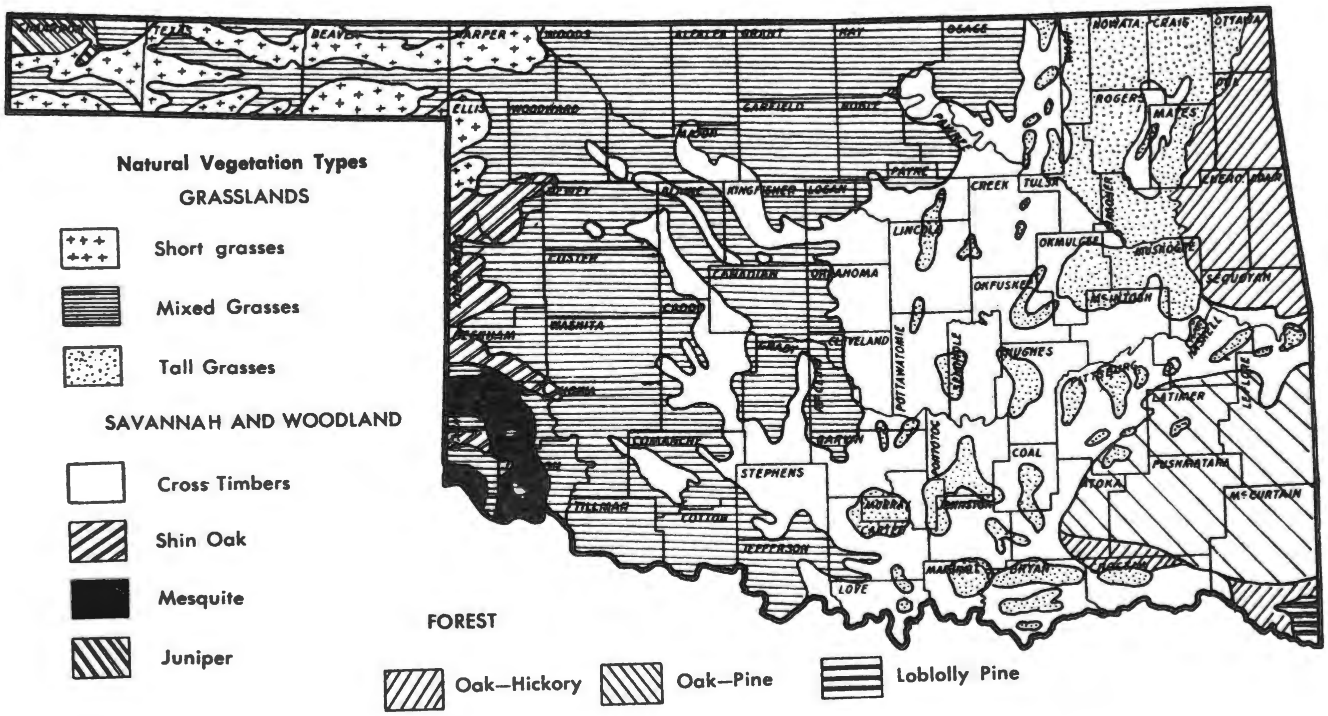


Fig. 3. Natural vegetation types in Oklahoma

blue-stem[1], switch grass, eastern gramagrass, Scribner Panicum, white tridens, hairy grama, Canadian wildrye, meadow foxtail, and buffalo grass. As a result of overgrazing, bermuda grass, prairie threeawn, and silver blue-stem are widely occurring grasses in the watershed. Overgrazing has a tendency to eliminate many of the characteristic grasses while it encourages such forbs as western ragweed, annual broomweed, western yarrow, and Carolina nightshade. Repetitive grazing reduces grass height. In many grassland areas of the watershed, grass height is less than six inches with much of the soil exposed.

The wooded Cross Timbers portions of the watershed (Fig. 3) are dominated by a blackjack/post oak cover type typified by blackjack oak, post oak, hickory, hackberry, American elm, and red bud. The understory and brush areas are dominated by sumacs, greenbriers, roughleaved dogwood, and grapevine. Much of the original Cross Timbers complex has been cleared for pastureland and crop productions. Very few of the sampled impoundments occurred within this vegetative type.

Crop land is a significant vegetative type within the watershed, usually occurring within the floodplain. The majority of all tillable land is planted in wheat, alfalfa, or lespedeza, either as a cash crop or for livestock grazing. It is in this crop land vegetative type that many of the small farm ponds have been constructed.

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[1]Refer to Appendix A for scientific names

## Land Use

### Socio-economic

The dominant socio-economic use of the watershed is agricultural, except for the Stillwater area which is the trade and industrial center for the watershed and the home of Oklahoma State University.

Wheat is the main crop in the watershed and used primarily as a forage crop rather than a cash crop. The more rolling areas are used for small grain-cattle farming. On some of the soils, grain sorghum is grown for cattle feed and the combine varieties are grown for grain. Mixed native grasses and alfalfa are made into hay and much land is devoted to native pasture. Some bermuda pastures are particularly utilized for dairy farming in the eastern portion where the Reddish Prairie blends with the Cross Timbers area. A large amount of pasture is also realized from winter wheat.

Land within the forested areas is primarily used for cattle grazing. Nearly all of the deeper soils have been eroded, contributing to the sandy and silty sediments of the eastward-flowing streams and valleys. The original farm population has dwindled. The small farms have been consolidated into larger units which support grazing and forage production; there is occasional oil and gas production.

The dominant recreational use of the land is for upland game hunting and farm pond fishing, activities which are primarily enjoyed by the landowner and his family. Public recreational areas exist at Lake Carl Blackwell, Lake McMurtry, and Boomer Lake.

It appears that the trend in land use is toward a more urban situation. The City of Stillwater is growing, and the supporting population of Oklahoma State University is requiring more housing and recreational facilities. While Noble and Logan Counties both showed a slight decline in population (1970 census), Payne County showed a marked increase, particularly within the city limits of Stillwater.

## Wildlife

Wildlife habitat in the watershed is characterized as the rural, agricultural farm-game type which supports a good diversity of game and non-game wildlife. Most tracts of favorable terrestrial wildlife habitat occur along fence and hedge rows, at forest/prairie ecotones, and in the gallery forests that develop along stream courses. Upland game birds such as bobwhite quail[2], mourning dove, and wild turkey are found in the fields, fence rows, and forested areas of the watershed in good numbers. Game mammals, including cottontail rabbit, fox squirrel, and white-tailed deer are common inhabitants of the late successional stages of farm, pasture land and gallery forests. Many non-game species of wildlife are residents or migrants of the watershed including the coyote, red-tailed hawk, and numerous species of birds.

Wetland habitat in the watershed is limited to small ($\sim$ 0.405 ha.) farm ponds and stock tanks which are considered marginal habitat and often overlooked in statewide waterfowl inventories (Lem Due, Okla. Dept. Wildl. Conservation, personal communication). However, in addition to the use of these wetlands by Anatidae, which provides the basis for this study, numerous species of other water birds (refer to Appendix B) are important components of the wetland habitat. Addition-

[2]Refer to Appendix B for scientific names.

al wetland habitat includes the larger reservoirs, SCS Watershed structures, and streams. Although not as abundant as farm ponds, these other wetland areas are important in the complete hydrological cycle of the watershed.

Appendix B is a listing of birds and mammals that are considered characteristic of the watershed and were observed as being either common or abundant in numbers.

## Sampled Impoundments

### Classification

The watershed includes impoundments ranging from small (less than .405 ha.) farm ponds to larger (greater than 200 ha.) multi-purpose reservoirs. The total number of impoundments within the 71,719 ha. watershed exceeds 1000, dominated in number by the small farm ponds (over 80 percent of the total). All impoundments in the watershed were classified according to the following sizes (n = total number in watershed):

0.040 - 0.405 ha., n = 924

0.406 - 4.05 ha., n = 205

4.06 - 40.50 ha., n = 5

40.60 - 200.0 ha., n = 3

greater than 200.0 ha., n = 1

Most of the small impoundments are classified as Wetland Type 4 (Inland Deep Fresh Marsh) and 5 (Inland Open Fresh) according to Shaw and Fredine (1956) and Class VA (Freshwater Permanent Ponds and Lakes) as defined by Stewart and Kantrud (1971). Although not tailored to deep water reservoirs, Shaw and Fredine's (1956) classification system would characterize the larger impoundments and reservoirs of the watershed as a modification of Wetland Type 5. The basic difference between impoundments in the Stillwater Creek Watershed and those in a northern pothole region watershed is water permanence. Late summer drought, typical of the SCW, has only a slight effect on the total number of available impoundments.

The distribution of impoundments within the watershed is not random, and is partially determined by topography, land use, soil type, and landowner requirements. There are more small (0.040 - 0.405 ha.) impoundments in the center of the watershed than either the western or eastern portion. The larger impoundments are located in the west-central portion of the watershed.

## Description

As stated previously, the utility of impoundments to waterfowl depends on a number of biotic and abiotic characteristics (Edminster 1964). The impoundments within Stillwater Creek Watershed exhibit a wide variation of these characteristics, as described in later chapters. A brief general description is presented at this time in order to characterize the sampled impoundments.

0.040 - 0.405 Surface Hectares. Impoundments in this category include the farm ponds and stock tanks so characteristic of this part of Oklahoma. These are the most numerous and widely occurring impoundments in the watershed and range from turbid, non-productive ponds to clear, highly productive ones. Farm ponds which are located in highly eroded and overgrazed watersheds are typically turbid, support few macroinvertebrates and little vegetation, and provide only marginal wildlife habitat (Fig. 4). Ponds located in properly grazed watersheds are usually clear, support good stands of emergent, floating, and submergent vegetation along with the attendant macroinvertebrates, and provide good wildlife habitat (Fig. 5).

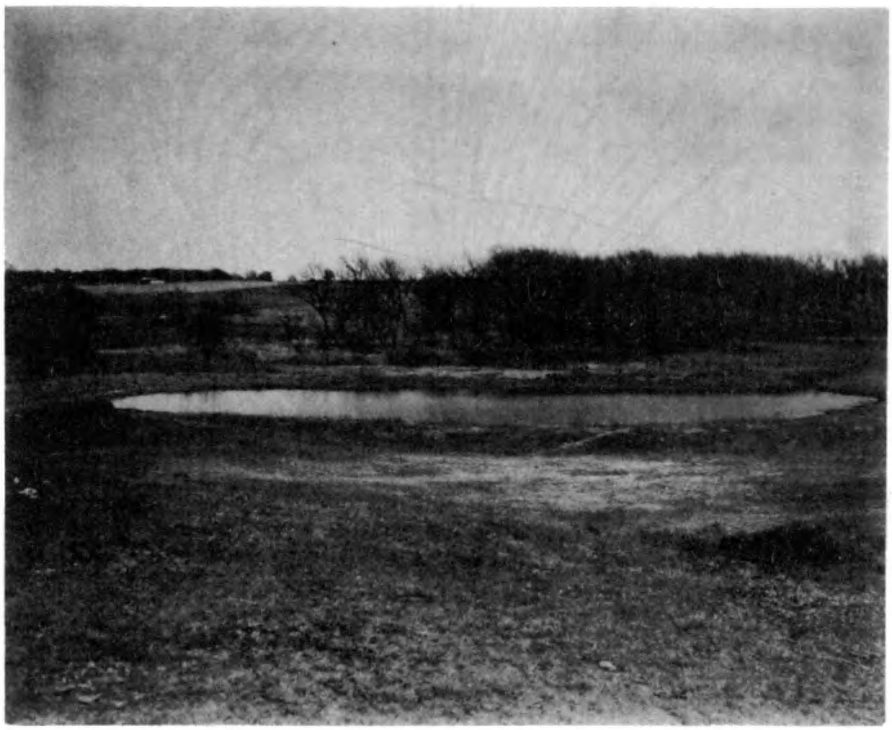

Fig. 4. Example of a farm pond in a highly eroded and overgrazed watershed

Impoundments in this category are not greatly affected by drought. Most experience only a slight lowering of water levels. In a few cases approximately 0.20 ha. shallow fresh marshes, i. e., Type 3 wetlands (Shaw and Fredine 1956), which are maintained by spillway seepage, have formed below the dams. These wetland areas usually dry up during the late summer drought and become unavailable to early fall migrants. Figure 6 illustrates a Type 3 wetland occurring within the watershed.

Fig. 5. Example of a farm pond located in a properly grazed, well managed watershed

<u>0.406 - 4.05 Surface Hectares.</u> This category includes farm ponds whose watersheds are capable of supporting a larger impoundment surface area and Soil Conservation Service Watershed structures which are usually 3 to 4 ha. in size. Although impoundments in this category are not as numerous as the smaller (0.040 - 0.405 ha.) ponds, they exhibit

the same degree of habitat variations.

Fig. 6. Example of a Type 3 wetland occurring in the Stillwater Creek Watershed

Due to the number of impoundments in this size group (108), a sampling scheme was used to select impoundments in this category for more intensive study. However, because of interest in PL 83-566 (Watershed Protection and Flood Prevention Act of 1956), all 12 SCS structures in this size category were included in the sample. These 12 impoundments, ranging in productivity and utility, include the following site numbers as defined by the Stillwater Creek Watershed

Work Plan (SCS, Stillwater, Oklahoma): 2, 3, 6, 7, 8, 10, 24, 28, 37, 48, 55, and 56. Three of these watershed structures are shown in Figures 7, 8, and 9.

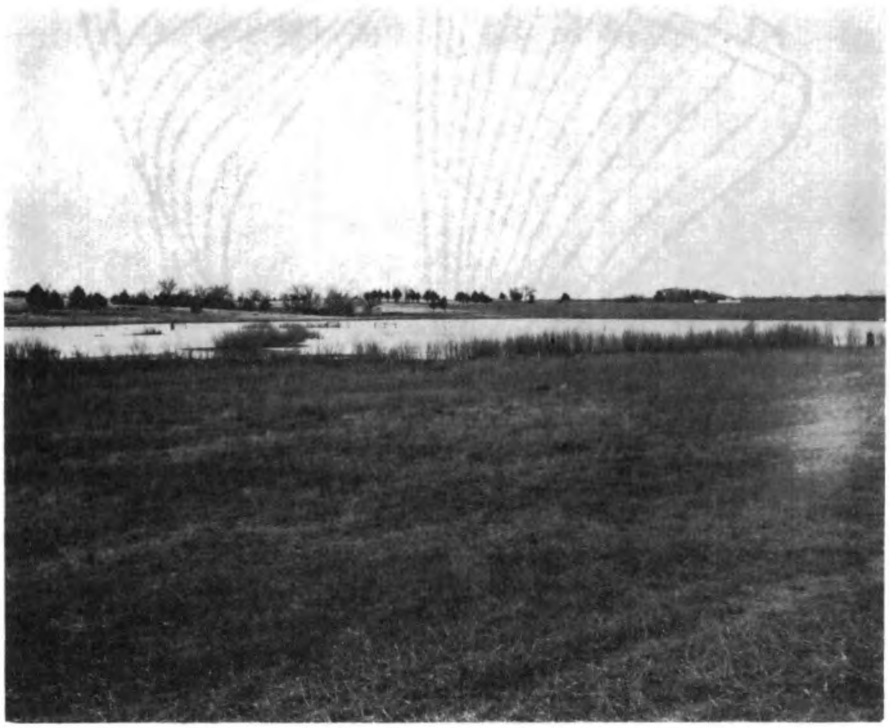

Fig. 7. Soil Conservation Service Structure No. 55, Stillwater Creek Watershed

<u>4.06 - 40.50 Surface Hectares</u>. Only three impoundments in this size category occur within the watershed and all three were intensively sampled. Two of these impoundments, Yost Reservoir (8.5 surface ha.) and Sanborn Lake (5 surface ha.), are well-known landmarks of the watershed and receive high amounts of public use.

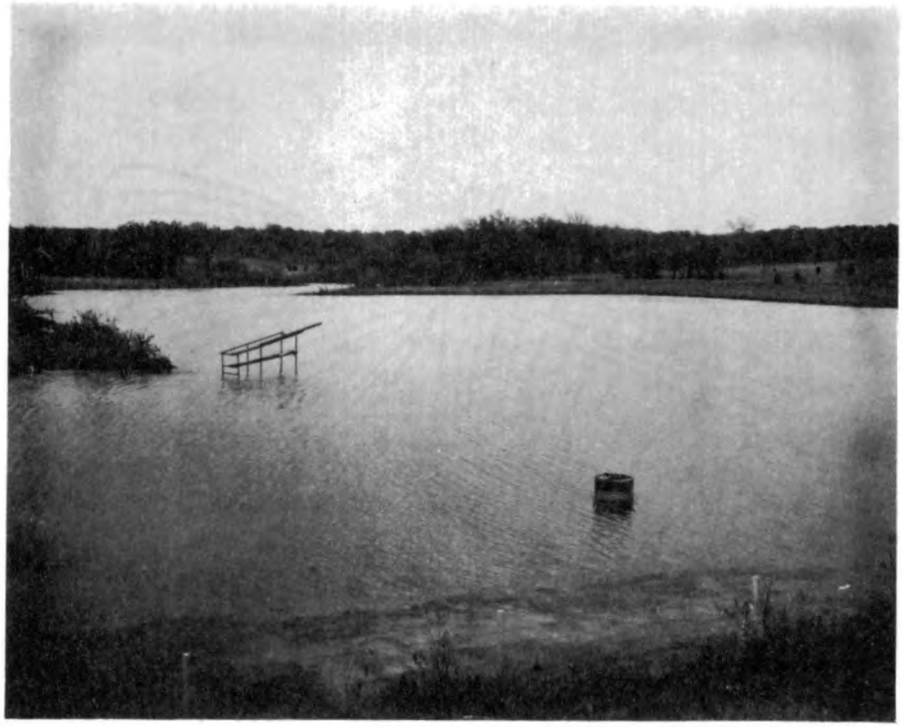

Fig. 8. Soil Conservation Service Structure No. 56, Stillwater Creek Watershed

<u>40.60 - 200.0 Surface Hectares</u>. Three impoundments occur in this category, and include the following: Lake McMurtry, Ham's Lake, and Boomer Lake.

Lake McMurtry (Fig. 10) is currently (July 1975) a 728 ha. SCS multi-purpose reservoir (site no. 40) that was completed in August 1970 and began to fill during this study. The approximate size from September 1971 to September 1972 was 100 ha. Lake McMurtry is owned by the City of Stillwater and is a public recreational area which also supplements the municipal water supply.

Ham's Lake (Fig. 11) is an SCS Watershed Structure (site no. 46) which has been enlarged for irrigation. Ownership of the watershed and the dam site includes Oklahoma State University and private landowners.

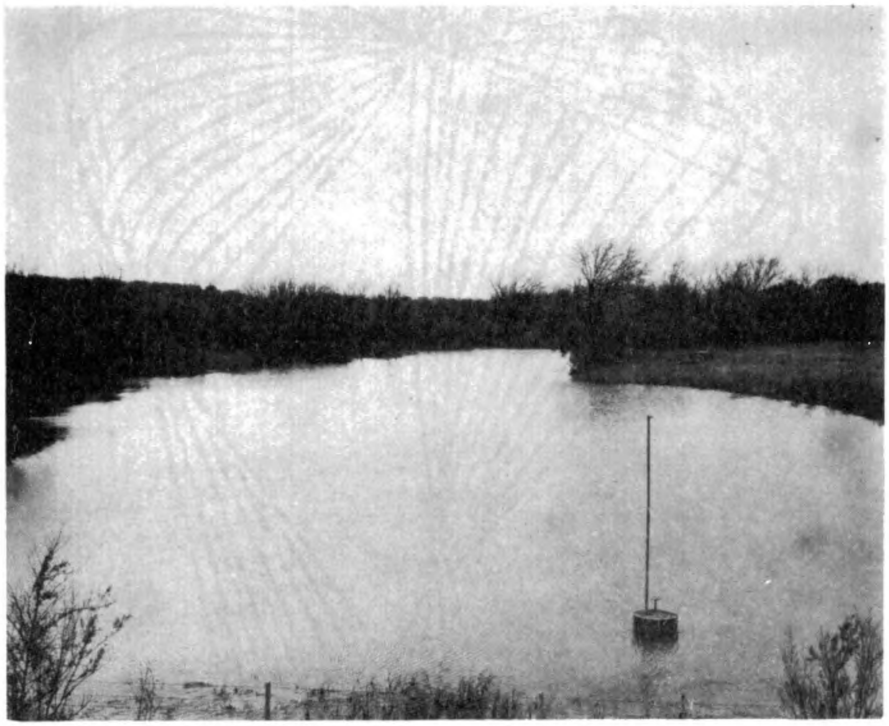

Fig. 9. Soil Conservation Service Structure No. 6,
Stillwater Creek Watershed

Boomer Lake is an 80 surface ha. reservoir located in the City of Stillwater and at one time was used for a municipal water supply. Currently the lake is the central feature of Boomer Lake Park, a public recreation area which is heavily used during most of the year. A housing development and blacktop road across the upper end are reducing the lake's attractiveness to waterfowl.

Fig. 10. Lake McMurtry, Stillwater Creek Watershed, from the west shore looking southeast as it began to fill shortly after completion (1971)

Greater than 200 Surface Hectares. Lake Carl Blackwell (approximately 750 surface ha. during this study), located about 10 km. west of Stillwater, was the only impoundment in the watershed over 200 surface ha. in size. Blackwell is used as a municipal water supply, and a major recreational area for north-central Oklahoma. Permanent cabins, fishing areas, waterfowl blinds, and attendant services dot the shoreline. The watershed's uplands are grazed by livestock and the flood plain is farmed for wheat and alfalfa. Lake Carl Blackwell is owned by Oklahoma State University and is used by various elements as a field research station and study area.

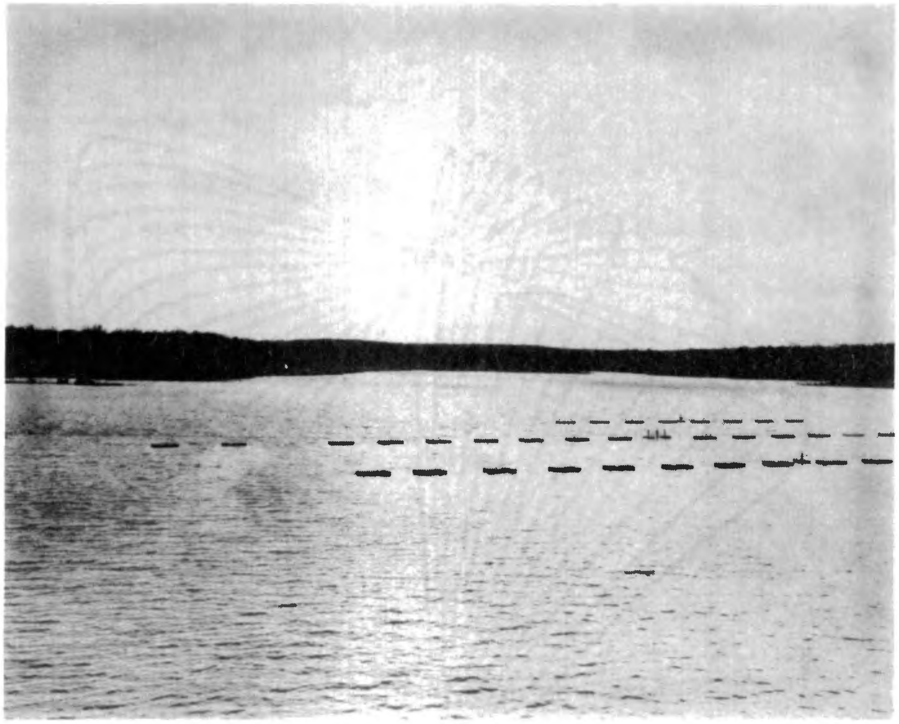

FIG. 11. Ham's Lake, Stillwater Creek Watershed, looking southeast from the dam

# CHAPTER III

# METHODS

## Introduction

The following summarizes the general procedures used to determine waterfowl numbers and their preference for habitat characteristics within Stillwater Creek Watershed:

(1) Seasonal waterfowl census on selected impoundments;

(2) Derivation of a waterfowl-use index for each sampled impoundment;

(3) Collection of weather data;

(4) Intensive survey of 19 Static habitat characteristics for each sampled impoundment;

(5) Seasonal survey of 5 Dynamic habitat characteristics for each sampled impoundment;

(6) Data reduction;

(7) Statistical analysis of habitat preference patterns; and

(8) Statistical analysis of weather influences.

## Impoundment Stratification

Approximately 1,100 impoundments occur within the 71,719 ha. study area, ranging in size from small (less than 0.2 ha.) farm ponds to large (greater than 200 ha.) multi-purpose reservoirs. With the aid of

U. S. Geological Survey Maps (7.5 minute series), Agricultural Stabilzation and Conservation Service (ASCS) photographs, and field reconnaissance, all impoundments were identified and stratified according to their surface acreage.[1] Determination of surface acreage was made with a plastic template of proper scale, which, when placed over each impoundment as identified on the appropriate maps and photos, provided an approximate estimate of surface acreage. Surface acreage was determined at spillway level, except for Lakes Blackwell and McMurtry whose surface acreage was significantly below that of the spillway.

Due to the large number of impoundments within the watershed, only a portion could be routinely censused for waterfowl; therefore, a sampling scheme was developed which is shown in Table I. All of the impoundments within the two large size categories were censused, whereas sampling intensity from the three smaller size categories (0.0405 - 0.405 ha., 0.406 - 4.050 ha. and 4.06 - 40.50 ha.) was 30, 49, and 60 percent respectively. These sampled impoundments were selected on a stratified random basis, due to the clumping of impoundments in the central portion of the watershed and the variety of habitat conditions. From field reconnaissance data collected in the spring of 1971, the impoundments were stratified into one of three general habitat quality categories (poor, fair, good) based on qualitative features such as amount of aquatic vegetation and degree of turbidity. An equal number of impoundments were randomly selected from each category.

[1]All field data were collected in English units and, where appropriate, converted to Metric units for presentation in this study.

TABLE I

SAMPLING SCHEME FOR WATERFOWL CENSUS

| | Impoundment Size Category in Ha. | | | | | |
|---|---|---|---|---|---|---|
| | 0.0405-0.4050 | 0.406-4.050 | 4.06-40.50 | 40.60-200 | >200 | Total |
| Total Number of Impoundments in Watershed | 924 | 205 | 5 | 3 | 1 | 1138 |
| (Percent of Total) | (81.2) | (18.0) | (0.4) | (0.3) | (0.1) | (100) |
| Number of Impoundments Visited for Waterfowl Census | 277 | 100 | 3 | 3 | 1 | 384 |
| (Percent of Category) | (30) | (49) | (60) | (100) | (100) | (34) |

## Waterfowl Census

### Sampling Scheme

A waterfowl census was conducted from August 29, 1971 through August 27, 1972 in order to establish the chronology and phenology of migration in the watershed and to determine the number and species of waterfowl using the various impoundment types. Waterfowl species and their abundance were determined on a seasonal basis defined as:

Fall Migration (Aug. 29 - Nov. 27, 1971)

Wintering Season (Nov. 28, 1971 - Feb. 26, 1972)

Spring Migration (Feb. 27 - May 27, 1972)

Summer Season (May 28 - Aug. 27, 1972)

The census was in the form of ground counts. Each impoundment selected for study was approached in an inconspicuous manner in order to avoid disturbance of waterfowl. With the aid of 7x30 binoculars, 50x spotting scope, and a portable tape recorder, the number of each waterfowl species was noted. Four predetermined travel routes were used on a rotation basis to eliminate impoundment bias. Each route included all impoundments in the last three size categories, and approximately 25 percent of the sampled impoundments in each of the two smaller size categories (0.0405 - 0.405 ha. and 0.406 - 4.050 ha.). Each of the four routes was travelled at least once a week and at one of the following three time periods selected on a rotation basis:

Sunrise to 1000 hours;

1000 hours to 1400 hours; and

1400 hours to sunset.

Each sampled impoundment was assigned an identification number based on its location in the watershed. Census data were transferred from the tape recorder to 80 column IBM data cards in order to computerize the census analysis. A data deck of approximately 2,000 cards, referred to as OB or observation deck, containing daily weather and census data was generated. Appendix C lists the individual column inputs for this data deck.

## Waterfowl-use Index

In order to measure the extent of impoundment preference, a seasonal waterfowl-use index (NWFL) was computed for each of the 384 impoundments included in the waterfowl census (Table I). The derivation of this index is as follows:

$$NWFL = TNW/A, \text{ where} \qquad (1)$$

TNW = total number of waterfowl observed per season, and A = surface acreage[2] of impoundment multiplied by the number of observations. The index actually represents a seasonal average of waterfowl observed per surface acre for each censused impoundment. To further illustrate the index, impoundment 154201 was censused 17 times in the fall of 1971. A total of 433 waterfowl were observed using this 7.2 acre impoundment during the fall migration. Using the formula previously defined,

$$433/(7.2 \times 17), \tag{1}$$

the fall average of waterfowl observed per surface acre (NWFL) for this impoundment was 3.54.

The seasonal waterfowl-use index is an important number in this study as it establishes waterfowl use patterns for the various habitat types. The index results were used in selecting those impoundments to be intensively studied, and became the cell input to the Analysis of Variance (AOV) tables constructed in the statistical analysis of habitat preference. Computation of the seasonal waterfowl-use index was done on computer. Input data (referred to as TD or Totals Deck) for the index were generated from the waterfowl census data and are described in Appendix C.

## Weather Data

Weather conditions have been shown to exert strong and varied influences on waterfowl movements and behavior (Barclay 1970; Welty 1962; Miskimmen 1955; Lawrence 1964; Diem and Lu 1960; and Bellrose 1970). In order to analyze the effects of weather on impoundment use patterns, detailed meterological data were compiled for each sampling

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[2]English units were used in the formula.

day of the 1971-72 waterfowl census. A portion of these data were obtained by direct reading or observations. The remainder were taken from the Daily Climatological Summaries for Stillwater, Oklahoma, published monthly by the Environmental Sciences Services Administration (ESSA) in Ashville, North Carolina. Weather data were recorded in various levels or degrees of intensities in order to facilitate the interpretation of weather and impoundment use patterns. Table II presents the type of weather data collected, level or degree of intensity, and method of collection. Daily weather parameters were coded onto 80 column IBM data cards along with the daily census data as described previously. The resultant data deck (referred to as OB or Observation Deck) is described in Appendix C.

## Intensive Impoundment Survey

### Impoundment Selection

An intensive survey of 100 impoundments was conducted concurrently with the waterfowl census in order to define and analyze those characteristics important in determining habitat preference by waterfowl. Impoundments used in the intensive survey were selected from the 384 impoundments included in the waterfowl census (Table III).

All but two impoundments in the three largest size categories were intensively surveyed. Selection of impoundments in the remaining two size categories (17 and 46 percent, respectively) was based on a pre-survey of 88 impoundments conducted from September through May of 1970-71. This pre-survey was conducted in order to characterize the impoundments and establish patterns of waterfowl habitat preference. The pre-

TABLE II

TYPE OF WEATHER DATA AND METHOD OF COLLECTION DURING THE 1971 - 72 WATERFOWL CENSUS

| Parameter | | Levels of Intensity | Method of collection |
|---|---|---|---|
| 1. | General Weather Situation | 1- Static<br>2- Changing (front in)<br>3- Clearing (front out) | ESSA |
| 2. | Visibility | 1- Below normal<br>2- Normal<br>3- Above normal | Direct Observation |
| 3. | Air Temperature | 1- Cold (<0° C)<br>2- Cool (0-10° C)<br>3- Warm (10-27° C)<br>4- Hot (>27° C) | Telethermometer |
| 4. | Wind Direction | 1- North<br>2- East<br>3- South<br>4- West | Direct Observation |
| 5. | Average Wind Speed | 1- 0-16 Kph<br>2- 16-32 Kph<br>3- 32-48 Kph<br>4- >48 Kph | Dwyer Wind Guage |
| 6. | Wind Chill Index | 1- >0° C<br>2- 0° to -12° C<br>3- -12 to -23° C<br>4- <-23° C | Nomograph |
| 7. | Precent of Cloud Cover | 1- 0-25<br>2- 25-50<br>3- 50-75<br>4- 75-100 | Direct Observation |
| 8. | Current Precipitation | 1- None<br>2- Light rain<br>3- Heavy rain<br>4- Snow/sleet | Direct Observation |
| 9. | Past Precipitation | 1- None in past 48 hrs<br>2- <5 cm in past 48 hrs<br>3- >5 cm in past 48 hrs | ESSA |

TABLE II (Continued)

| | Parameter | Levels of Intensity | Method of Collection |
|---|---|---|---|
| 10. | Barometric | 1- Steady<br>2- Rising<br>3- Falling | ESSA |
| 11. | Distance Watershed is Behind Major Front | 1- >1600 km<br>2- 1600-800 km<br>3- 800-400 km<br>4- 400-160 km<br>5- <160 km<br>6- No defined front | ESSA |
| 12. | Distance Watershed is Ahead of a Major Front | 1- >1600 km<br>2- 1600-800 km<br>3- 800-400 km<br>4- 400-160 km<br>5- <160 km<br>6- No defined front | ESSA |
| 13. | Amount of Ice Cover on Impoundment | 1- None<br>2- <50%<br>3- >50% | Direct Observation |

survey established a waterfowl-use-day figure for the pre-surveyed impoundments and served as the basis for selecting preferred and non-preferred impoundments. Impoundments with a seasonal average waterfowl-use-day of less than 5 were considered non-preferred. (Approximately 60 percent of the impoundments in the two smallest size categories intensively surveyed during 1971-72 were non-preferred (Table IV)). Final selection of impoundments was as near a stratified random design as landowner access and sampling logistics would permit.

TABLE III

SAMPLING SCHEME FOR INTENSIVE IMPOUNDMENT SURVEY

| | Impoundment Size Category in Ha. | | | | | |
|---|---|---|---|---|---|---|
| | 0.0405-0.4050 | 0.406-4.050 | 4.06-40.50 | 40.60-200.0 | >200 | Total |
| Total Number of Impoundments in Watershed | 924 | 205 | 5 | 3 | 1 | 1138 |
| Number of Impoundments Censused for Waterfowl | 277 | 100 | 3 | 3 | 1 | 384 |
| Number of Census Impoundments Intensively Surveyed | 47 | 46 | 3 | 3 | 1 | 100 |
| (Percent of Census Total) | (17) | (46) | (100) | (100) | (100) | (38) |

Habitat characteristics intensively surveyed were broken down into two main categories - Static (relatively stable) and Dynamic (changing with the seasons). Data from both categories were coded onto 80 column IBM data cards (referred to as SD or static deck) and served as input for statistical analyses. Appendix C describes this data deck.

TABLE IV

WATERFOWL USE OF IMPOUNDMENTS DURING THE PRE-SURVEY, SEPTEMBER 1970 - MAY 1971

| Impoundment Size Category in Ha. | Preferred/Total Surveyed | Percent Preferred |
|---|---|---|
| 0.0405 - 0.405 | 23/47 | 49 |
| 0.406 - 4.05 | 12/31 | 39 |
| 4.06 - 40.50 | 3/5 | 60 |
| 40.60 - 200 | 2/2 | 100 |
| > 200 | 1/1 | 100 |
| Total | 41/86 | 48 |

## Static Characteristics

In other geographical areas, especially on the northern breeding grounds, it has been shown that impoundment use by waterfowl is governed by such factors as geographical location, water quality, physical characteristics, and other environmental influences. Nineteen relatively changeless (Static) habitat characteristics were selected for intensive study on the basis of literature reviews of similar studies (Buller 1964; Barstow 1957; Bennett 1938; Hancock 1951; Keith 1961; Metzen 1966; and others) and a 1970-71 pre-survey of habitat conditions in the Stillwater Creek Watershed. Static characteristics for each of the 100 intensive survey impoundments were measured seasonally and categorized as shown in Table V. Methods for collection of static data were as follows:

Impoundment Size. U. S. Geological Survey topographic maps, ASCS photographs, and field reconnaissance were used to determine impoundment size on a surface acreage basis. Precise measurement was not essential since each impoundment was placed in one of five size categories.

Orientation of Dam. Determination was made with a compass.

Visibility from Roadway. A yes or no question based on whether the impoundment's water surface could be viewed from a roadway.

Land Use of Surrounding Watershed. Watershed boundaries were determined from maps and field reconnaissance. Land use determination was by visual observation. "Human Habitation" usually meant a close location (within 0.4 km.) to houses or farm buildings. "Crops/Farm Land" in the watershed consisted of wheat and other crops. "Grazing" refers to natural or sown native grassland or cropland (e.g. wheat) that is grazed by livestock. "Oil Field" operations were characterized by pumps and pump head, equipment buildings and oil storage tanks. "Idle" represents a land use situation where none of the above conditions are descriptive of the watershed, and where no apparent consumptive land use practices are being performed.

TABLE V

STATIC HABITAT CHARACTERISTICS INTENSIVELY SURVEYED FOR 100 IMPOUNDMENTS AND ASSOCIATED WATERSHEDS

| Static Characteristics | Categories |
|---|---|
| 1. Size | 1- 0.0405-0.405 ha<br>2- 0.406-4.05 ha<br>3- 4.06-40.50 ha<br>4- 40.60-200.0 ha<br>5- >200 ha |
| 2. Orientation of Dam | 1- North<br>2- East<br>3- South<br>4- West |
| 3. Visibility from Roadway | 1- Yes<br>2- No |
| 4. Land Use of Watershed | 1- Human habitation<br>2- Crops/farm land<br>3- Crops/grazing<br>4- Oil field<br>5- Idle |
| 5. Surrounding Topography | 1- Open<br>2- Semi-closed<br>3- Closed |
| 6. Extent of Livestock Grazing | 1- None<br>2- Lightly grazed<br>3- Overgrazed<br>4- Heavily overgrazed |
| 7. Erosion Conditions | 1- No erosion<br>2- Light<br>3- Moderate<br>4- Severe |
| 8. Shoreline Development Index | 1- Round<br>2- Moderate<br>3- Extensive |
| 9. Maximum Depth-Surface Relation | 1- Low<br>2- Moderate<br>3- High |
| 10. Cattle Activity at Edge | 1- None<br>2- Light<br>3- Extensive |
| 11. Distance to Major Food Crops | 1- <0.4km<br>2- 0.4-0.8 km<br>3- 0.8-1.6 km<br>4- >1.6 km |

TABLE V (Continued)

| Static Characteristics | Categories |
|---|---|
| 12. Distance to Human Dwellings | 1- <0.4 km<br>2- 0.4-0.8 km<br>3- 0.8-1.6 km<br>4- >1.6 km |
| 13. Distance to Section Road | 1- <0.4 km<br>2- 0.4-0.8 km<br>3- 0.8-1.6 km<br>4- >1.6 km |
| 14. Distance to Major Impoundments | 1- <0.4 km<br>2- 0.4-1.6 km<br>3- 1.6-5.0 km<br>4- 5.0-10.0 km<br>5- 10.0-16.0 km<br>6- >16.0 km |
| 15. Ownership | 1- Private<br>2- Government |
| 16. Degree of Habitat Management | 1- Habitat leased for hunting/management techniques used<br>2- Leased/no management techniques<br>3- None |
| 17. Extent of Human Disturbance | 1- None<br>2- Slight<br>3- Moderate<br>4- Heavy |
| 18. Degree of Land Posting | 1- Posted<br>2- Not posted |
| 19. Presence of Exposed Shoreline | 1- Present<br>2- Not present |

Surrounding Topography. Assignment of each surveyed impoundment into one of three categories was by a visual qualitative determination. An "Open" impoundment was characterized by a lack of a defined drainage pattern into the impoundment and a small watershed-to-surface acreage ratio. Most "Open" impoundments were located in pasture or crop land and were without any deciduous shoreline vegetation. A "Closed" impoundment was typified by a well defined watershed drainage pattern. The surrounding watershed is on a higher topographic elevation. A "Closed" impoundment usually had a large watershed-to-surface acreage ratio and the shoreline was usually ringed with deciduous vegetation. A "Semi-closed" impoundment was described as being intermediate between "Closed" and "Open".

Extent of Livestock Grazing. Indicator species were used to categorize each surveyed watershed into one of four grazing conditions (Table V), as described by Phillips Petroleum Company (1959). The "None" category consists of a mixed grass situation with such dominants as big bluestem, little bluestem, switchgrass, eastern gramagrass and Canadian wildrye reaching a heighth of approximately 0.6 - 1.2 m., and producing a thick "carpet" of surface litter. Another standard indicator for this category was high diversity of vegetative species. The "Lightly Grazed" category was characterized by a lower diversity index with the bluestems yielding to bermuda grass, prairie threeawn, and such forbes as western ragweed and Carolina nightshade. Additionally, grass heighth was usually below 0.6 m. and the surface litter is reduced. Watersheds categorized as "Overgrazed" were low in vegetative diversity with remaining growth limited to less than 0.3 m. Dominant vegetation includes prairie threeawn, ragweeds, broomweed, western yarrow, and other forbes.

The native grasses (e.g., bluestems) have practically been eliminated, and about 50 percent of the ground is devoid of vegetative litter. The "Heavily Overgrazed" condition is characterized by a very low diversity dominated by annual broomweed and western yarrow. The complete lack of ground litter in this category creates surface erosion of enough severity to eliminate any sustained grazing.

Erosion Conditions. Determination of erosion conditions was by visual observations and a qualitative placement of each surveyed watershed into one of four categories (Table V). The "No Erosion" category is characterized by good ground cover and no signs of sheet or gully erosion. "Light" erosion conditions are typified by surface erosion usually due to overgrazing. The "Moderate" condition is defined as a watershed with moderate to heavy gully erosion principally along the banks of the tributary streams. "Severe" erosion is characterized by extensive gully and surface or sheet erosion which significantly reduces the amount of ground cover. Under the conditions of "Moderate" and "Severe" the impoundment usually remains turbid due to the constant input of clay silt. Throughout SCW there is a close relationship between grazing conditions and the degree of erosion.

Shoreline Development Index. Shoreline Development Index is an expression of the irregularity of the impoundment shoreline based on the ratio of shoreline length to surface acreage. In theory, a completely round impoundment would have an index of 1.0 while a highly configured impoundment would have a high index. Determination of the index values was made with a compensating polar planimeter using techniques described by Welch (1948:93-94). Each surveyed impoundment was placed in one of three categories (Table V).

Maximum Depth - Surface Relation. This parameter is a measurement of the relationship of depth to horizontal extent. A shallow impoundment with gradual gradation in depth from the edge to the deepest portion will have a low ratio. A deep impoundment with a steep horizontal extent will have a high ratio. Determination of this relation for each surveyed impoundment was made using techniques described by Welch (1948:78). Each impoundment was placed in one of three categories (Table V).

Cattle Activity at Edge. Cattle activity refers to the amount and degree of shoreline alteration resulting from livestock activity. Assignment of each impoundment into one of three categories (Table V) was by qualitative observation. The "Light" category is characterized by a partial destruction of shoreline vegetation during the spring grazing season. The "Extensive" category is typified by complete destruction of shoreline vegetation during all seasons with a continual disturbance of shoreline soil.

Distance to Major Food Crops. The distance to the nearest major cultivated food source (e.g., wheat, maize, etc.) was measured for each surveyed impoundment and placed in one of four distance categories as shown in Table V.

Distance to Human Dwellings. The distance to the nearest inhabited human dwellings, including farm buildings currently in use, was measured for each sampled impoundment and placed in one of four distance categories (Table V).

Distance to Section Road. The distance to the nearest section road was measured for each surveyed impoundment and placed in one of four distance categories (Table V).

Distance to a Major Impoundment. The distance to the nearest major impoundment was measured for each surveyed impoundment and placed in one of six distance categories (Table V). Nearest impoundment is defined as one of the following: Lake Carl Blackwell, Lake McMurtry, Ham's Lake, and Boomer Lake.

Ownership. Ownership was determined by personal contact and landowner interviews. Each surveyed impoundment was placed in either a "Private" or a "Government" category. "Government" ownership and/or control includes Soil Conservation Service watershed structures, and municipal water supply structures.

Degree of Habitat Management. Determination was made by landowner and hunter interviews resulting in the placement of each surveyed impoundment into one of three management categories (Table V). The "Habitat Leased for Hunting/Management Techniques Used" category refers to those impoundments that were leased specifically for waterfowl hunting with habitat management techniques (e.g., plantings, water control, burning, etc.) being practiced by the leasee. Impoundments that were leased for waterfowl hunting but had no management techniques practiced were placed in the "Leased/No Management Techniques" category. All other impoundments were placed in the last category, "None", indicating that the impoundment was not leased or managed for waterfowl hunting.

Extent of Human Disturbance. Extent of human disturbance was determined by qualitative observations and contacts with individual landowners. The "Heavy" category is characterized by those watersheds that contain picnic tables, boat and swimming docks, fishing access areas, hunting facilities, and receive seasonal public use. The "Moderate" category is typified by those watersheds that have some recreational facilities, as described above, but are used exclusively by the landowner and his family. Impoundments that are infrequently visited by fishermen, hunters, and others were placed in the "Slight" category. The "None" category refers to those impoundments which showed no signs of human disturbance and are rarely visited during any season.

Land Posting. Determination was made by visual observation of posted signs near or around the impoundment and its watershed. Each surveyed impoundment was placed in either a "Posted" or a "Not Posted" category.

Presence of Exposed Shoreline Margin. In some cases, continued lowering of water levels had created extensive exposed shoreline margins which lacked any substantial vegetation. Determination into a "Present" or "Not Present" category was made by visual observations for each surveyed impoundment.

## Dynamic Characteristics

Previous studies of waterfowl habitat on the breeding grounds indicate that habitat preference is affected by such Dynamic (changing) factors as water quality, vegetative production, and water levels (Arner et al. 1970; Bennett 1938; Bensen and Foley 1956; Bue 1964; Cassel and Stewart 1969; Greenwell 1952; Krull 1969; Moyle 1956; Trauger 1967; and others). In order to determine the influence of dynamic characteristics on habitat selection in the Stillwater Creek Watershed, five characteristics (Table VI) were measured for each of the 100 intensively surveyed impoundments. Methods and techniques used for collection of these data were as follows:

Turbidity. Turbidity was measured with a Bausch and Lomb Spectronic

20 Colorimeter calibrated against a Jackson Turbidimeter and expressed as "Jackson Turbidity Units (JTU)". Water samples were collected with a Kemmerer bottle at the surface and as near the bottom of the impoundment as possible. Samples were collected monthly and averaged to give a seasonal turbidity figure. Since turbidity is dependent upon wind action and stream inflow, samples were taken only during times of quiescence. Each surveyed impoundment was categorized, on a seasonal basis, into one of three turbidity categories based on the percent of light transmittance - "Clear" (greater than 80 percent transmittance), "Intermediate" (between 40 and 80 percent), and "Turbid" (less than 40 percent).

TABLE VI

DYNAMIC HABITAT CHARACTERISTICS MEASURED FOR 100 IMPOUNDMENTS

| Characteristic | Categories | Sampling Frequency |
|---|---|---|
| 1. Turbidity | 1- Clear<br>2- Intermediate<br>3- Turbid | Seasonal Average of Monthly Samples |
| 2. Total Alkalinity | 1- Low (< 50 ppm)<br>2- Moderate (50 - 150 ppm)<br>3- High (> 150 ppm) | Seasonal Average of Monthly Samples |
| 3. Aquatic Vegetation Index | 1- High (> 10)<br>2- Medium (1.1-10.0)<br>3- Low (< 1.0) | Seasonal |
| 4. Macroinvertebrate Abundance | 1- Low (< 500)<br>2- High (> 500) | Seasonal |
| 5. Water Level | 1- Below Normal<br>2- Normal<br>3- Above Normal | Seasonal Average of Weekly Samples |

Total Alkalinity. Total $CaCO_3$ alkalinity was determined from water samples collected in a Kemmerer bottle by titrating phenolpthlein and methyl green indicators with 0.02 N sulfuric acid. Monthly samples, collected 2-4 hours after sunset, were measured for total alkalinity and averaged to obtain a seasonal value for each surveyed impoundment. Each impoundment was placed in either a Low, Moderate or High alkalinity category based on the seasonal average (Table VI). Since total alkalinity may be considered a "rough" index of impoundment productivity (Moyle 1956), this permitted a comparison of habitat selection by degree of habitat productivity.

Aquatic Vegetation Index. A seasonal aquatic vegetation index was determined for each of the surveyed impoundments in order to express the relative abundance of important waterfowl foods. The derivation of this index is as follows:

$$\text{Impoundment Vegetation Index} = \sum_{i=1}^{n} (X \cdot Y_i \cdot Z_i), \qquad (2)$$

where X= size of impoundment; $Y_i$= percent of cover for ith species; $Z_i$= food value index for ith species; and n= number of aquatic food plants with a coverage greater than 10 percent. Percent plant cover was estimated by a visual observation of submergent, emmergent, and floating vegetation for each surveyed impoundment. The food value index is a numerical figure representing the volumetric percentage of specific food plants found in Central Flyway waterfowl as defined by Martin and Uhler (1951). For example, a 10 acre impoundment with 25 percent coverage of *Potomogeton* (food value index of 13.29), 10 percent coverage of *Polygonum* (food value index of 6.69), and 25 percent coverage of *Chara* (food value index of 2.48), would have a vegetation index of 46.12 as shown below:

$$\text{Index} = (10)(.25)(13.29) + (10)(.10)(6.69) + (10)(.25)(2.48) = 46.12 \qquad (2)$$

After seasonal computation of a vegetation index, each impoundment was placed in one of three categories based on the computed index (Table VI).

Macroinvertebrate Abundance. A seasonal macroinvertebrate abundance was determined for each surveyed impoundment in order to express the availability of macroinvertebrates as a source of food for migrating waterfowl. Sampling consisted of sweeping the water (30 cm. below the surface) with a No. 18 U. S. Standard Sieve at the emergent/submergent vegetational ecotone. The number of sweeps per impoundment was based on impoundment size; two equally spaced sweeps per surface acreage up to 100 sweeps. The number of macroforms counted per sweep were added together and a seasonal total was computed for each impoundment. Each impoundment was placed in either a High or a Low category (Table VI), representative of macroinvertebrate abundance.

# Data Analysis

## Data Reduction

All field data were transferred and coded on to IBM 80 column data cards. Information coded into the Static Deck (Appendix C) included, for each intensively surveyed impoundment (100), an identification code, size category, total surface acreage, and treatment levels for both the Static and Dynamic habitat characteristics (Tables V and VI). Data coded into the Observation Deck (Appendix C) included, for each observation (over 4,000) an impoundment identification number, a season and week code, levels of intensity for weather parameters (Table II), and the total number of waterfowl observed, by individual species, for each sampled impoundment. A third data deck, Totals Deck (Appendix C), was generated by computer which was used in the statistical analyses of Static and Dynamic habitat characteristics. This deck included, for each intensively surveyed impoundment, an impoundment identification number, a season and size code, levels of treatment for the habitat characteristics, total number of waterfowl observed by seasons, impoundment acreage, and the number of observations within each season.

## Waterfowl Census

Chronology of waterfowl migrating through the watershed was determined by a weekly summation of waterfowl numbers and species. All summation was by computer using the data contained in the Observation Deck. Various summation routines were generated to aid in the analysis of seasonal waterfowl movements. Table VII presents a listing of these routines and their output.

TABLE VII

SUMMATION ROUTINES AND OUTPUT USED TO ASSESS MIGRATION CHRONOLOGY IN THE STILLWATER CREEK WATERSHED

| Summation Routine | Output |
|---|---|
| 1. Weekly and Seasonal Totals | a. Weekly Total of Waterfowl by Species |
| | b. Total Weekly Sum of All Waterfowl |
| | c. Seasonal Total of Waterfowl by Species |
| | d. Seasonal Totals of All Waterfowl |
| | e. Weekly and Seasonal Total Observed Each Week |
| | f. Percent of Seasonal Total Observed Each Week |
| 2. Weekly and Seasonal Percentages | a. For Each Species, Percent of Seasonal Total Observed Each Week |
| | b. For Each Species, Percent of Seasonal Total For All Waterfowl |
| 3. Impoundment Weekly and Seasonal Totals | a. Weekly Species Total for Each Intensively Surveyed Impoundment |
| | b. Seasonal Species Totals for Each Intensively Surveyed Impoundment |
| | c. Seasonal Average of Waterfowl Use Days (Species Total/Number of Observations |

## Habitat Preference

A two-way classification of Analyses of Variance (AOV) was the statistic used to determine significant differences in habitat preference. A separate two-way (RxC) AOV (Snedecor and Cochran 1962) was computed for each of the 19 Static and 5 Dynamic habitat characteristics. Each AOV was generated by computer using the "Statistical Analyses System (SAS)" (Barr and Goodnight 1971) developed at North Carolina State University. This system was selected for its mathematical compensation of unequal cell sizes. Cell input consisted of the seasonal waterfowl use index generated from the waterfowl census. For each AOV, the Row (R) corresponds to the seasonal effect and Column (C) to the level of intensity of the specific habitat characteristics being analyzed (Table VIII).

TABLE VIII

EXAMPLE OF A TWO-WAY AOV USED TO TEST FOR SIGNIFICANT DIFFERENCE AMONG HABITAT CHARACTERISTICS

| 2-way AOV for Impoundment Size | | | | | |
|---|---|---|---|---|---|
| Rows (Seasons) | Columns (Size Categories in Ha.) | | | | |
| | 1 (0.0405-0.405) | 2 (0.406-4.05) | 3 (4.06-40.50) | 4 (40.60-200) | 5 (>200) |
| Fall | 1.4,...,2.5[a] n=47 | ... n=46[b] | ... n=3 | ... n=3 | 3.5 n=1 |
| Winter | 2.6,... n=47 | ... n=46 | ... n=3 | ... n=3 | 4.6 n=1 |
| Spring | 9.8,... n=47 | ... n=46 | ... n=3 | ... n=3 | 6.7 n=1 |

[a] Indicates the average seasonal waterfowl-use index (NWFL) for each impoundment in this size category.

[b] n refers to the number of inputs to that cell.

Tests of significance due to seasonal effect, habitat effect, and interaction were made at two confidence levels, $p < 0.10$, and $p < 0.25$. Each category of a significant habitat characteristic was plotted on a seasonal basis in order to identify the category contributing to significance.

## Weather Influences

Thirteen two-way AOV's were generated to test for significant differences due to weather influences. Analyses were by computer using an AOV program developed by UCLA (1965) for equal cell sizes. Cell input was the seasonal mean of waterfowl counted per observation for each level of the 13 weather parameters. Tests for significance were made at $p < 0.10$ and $p < 0.25$. The analysis of variance tested for differences in the seasonal mean number of waterfowl due to the effects of the thirteen weather parameters. The Newman-Keuls test (Snedecor and Cochran 1967) was used to indicate, for each weather parameter, which level was responsible for any size differences that appear in the AOV.

# CHAPTER IV

# RESULTS AND DISCUSSIONS

## Migration Chronology through the Watershed

Composition of waterfowl species in the watershed for 1971-72 was similar to that reported by Buller (1964), Metzen (1966), and Barstow (1957) for other years. Over 118 thousand waterfowl (Anatidae) were counted in over 1800 observations from August 29, 1971 to August 27, 1972 (Table IX). The average number of waterfowl counted per observation was 66. Twenty-three waterfowl species were observed using the 384 impoundments sampled in the waterfowl census. Dabblers (Anatinae) accounted for 62 percent of all species observed; divers (Aythyinae and Oxyurinae) 20 percent; mergansers (Merginae) 17 percent; geese and swans (Cygninae and Anserinae) 1 percent. Miscellaneous species (Table IX) included whistling swan, black duck, wood duck, and cinnamon teal.

The mallard was the most common species observed in the watershed accounting for over 22 percent of all species observed. The common merganser, contributing 17 percent to all waterfowl observed, was concentrated in large numbers during the winter on primarily two impoundments - Lakes Carl Blackwell and McMurtry. Over 5 thousand common mergansers were counted in a one day period during the winter using Lake Blackwell. The gadwall and wigeon were important dabblers

TABLE IX

WATERFOWL OBSERVED IN THE STILLWATER CREEK WATERSHED
FROM AUGUST 29, 1971 TO AUGUST 27, 1972

| Species | Total Observed | Percent of Total |
|---|---|---|
| Mallard | 26,165 | 22.15 |
| Common Merganser | 20,068 | 16.99 |
| Wigeon | 10,592 | 8.97 |
| Gadwall | 10,116 | 8.56 |
| Pintail | 9,814 | 8.31 |
| Ring-necked Duck | 9,007 | 7.63 |
| Green-winged Teal | 8,094 | 6.85 |
| Lesser Scaup | 6,960 | 5.89 |
| Blue-winged Teal | 5,168 | 4.38 |
| Canvasback | 3,718 | 3.15 |
| Redhead | 3,136 | 2.65 |
| Shoveler | 2,913 | 2.47 |
| Canada Goose | 1,005 | 0.85 |
| Ruddy Duck | 374 | 0.32 |
| Snow/Blue Goose | 340 | 0.29 |
| Bufflehead | 243 | 0.21 |
| Hooded Merganser | 175 | 0.15 |
| American Goldeneye | 80 | 0.07 |
| White-fronted Goose | 42 | 0.04 |
| Miscellaneous Species | 42 | 0.04 |
| Total[a] | 118,120[b] | 100.00 |

[a]Total waterfowl counted in over 1800 observations

[b]Average number of waterfowl counted per observation is 66

together amounting to over 18 percent of the total waterfowl observed. The green - and blue-winged teal combined, contributed over 11 percent to the total number of waterfowl observed, comparing similarly with Federal (U.S. Fish and Wildl. Serv. 1972) and Central Flyway figures (Buller 1964). The ring-necked duck was the most numerous diver observed, replacing the redhead as the dominant diver. Redhead and canvasback percentages were lower than that reported in earlier years, perhaps due to the overall decline in their numbers as a result of a reduction in breeding habitat.

The weekly fluctuations in the number of waterfowl counted per observation for all seasons is shown in Figure 12. The fall build-up occurring the sixth and seventh week (October 4-16, 1971), was dominated by early migrants (e.g., wigeon, gadwall, blue- and green-winged teal). Although the rapid decline in waterfowl numbers on the eighth week coincided with the opening of the Oklahoma waterfowl hunting season (October 16, 1971), weather conditions may have been the stronger influence in reducing population levels. Weather data reveals that a cold, wet low front moved through the watershed on October 14, 1971, two days prior to the opening of the hunting season. Analysis of weather influences (presented later in this thesis) indicates that cold, wet weather fronts are influential in reducing waterfowl populations in the watershed. A similar decline in waterfowl numbers the week of Oklahoma's hunting season, was observed in 1972, 1973 and 1974 (J. S. Barclay, personal communication). In each year, the decrease in waterfowl numbers was associated with a major cold front and rain system on or 1 - 3 days prior to the opening day of the season.

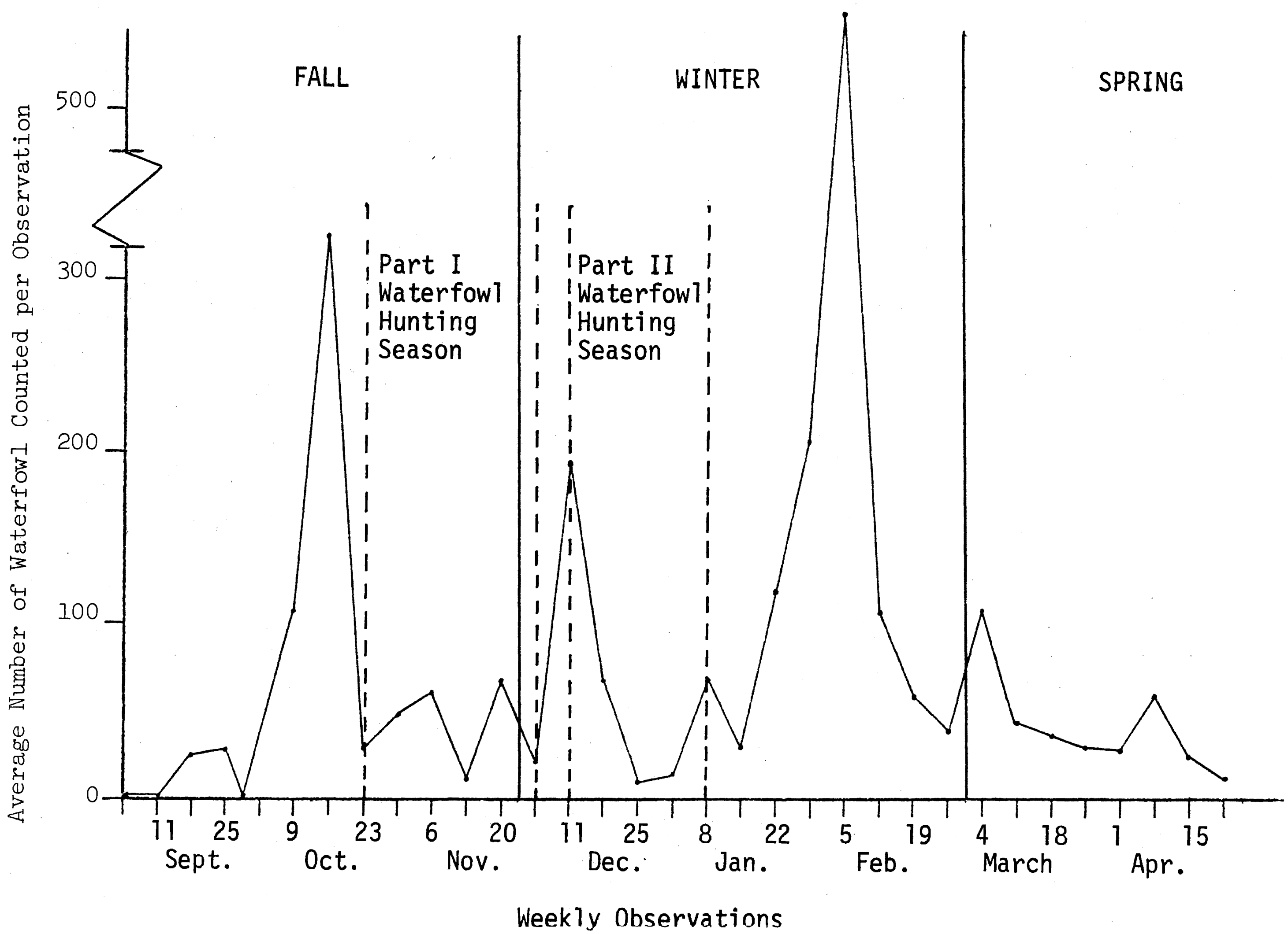


Fig. 12. Weekly fluctuations in the total number of waterfowl counted per observation in the Stillwater Creek Watershed from August 29, 1971 to April 22, 1972

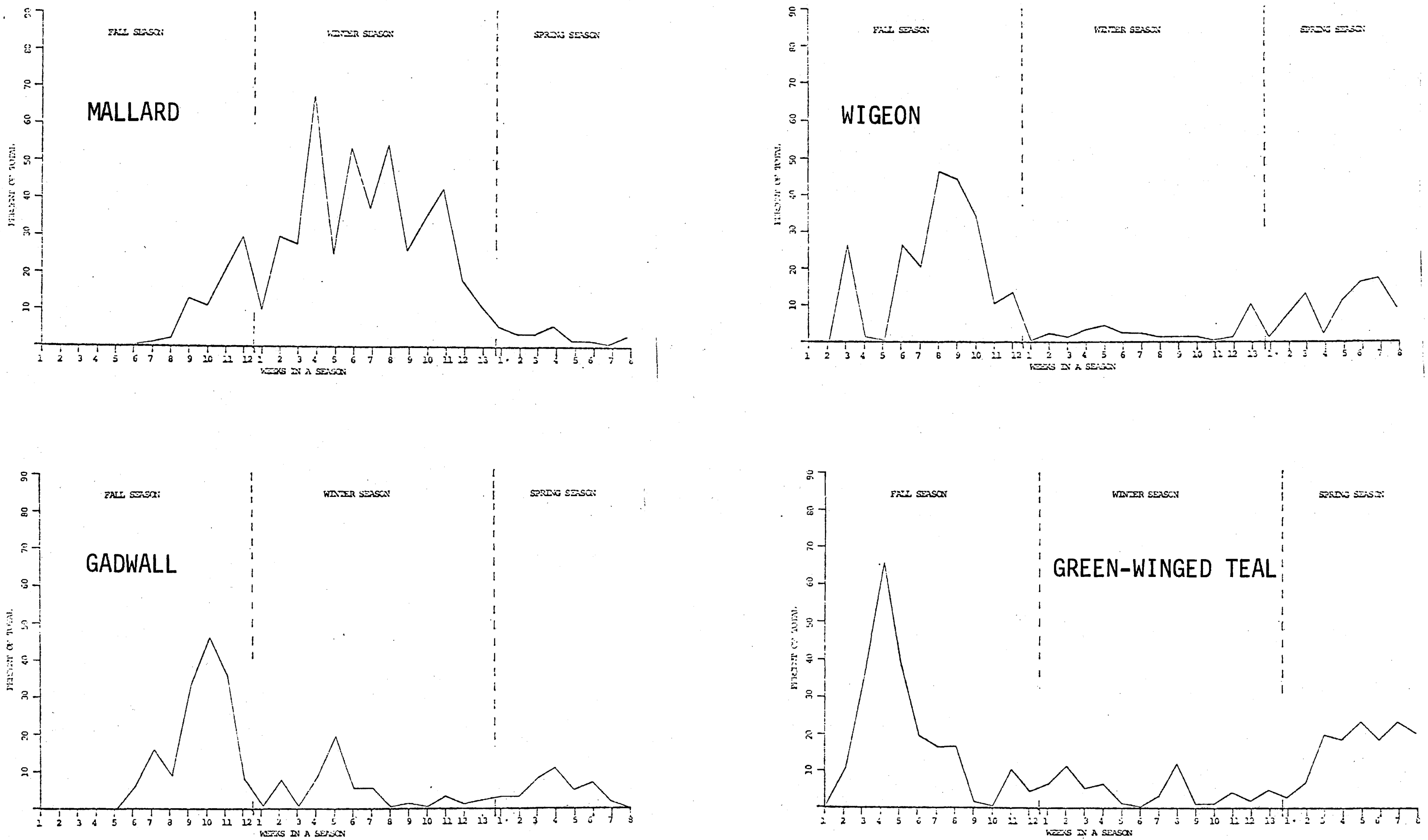


Fig. 13. Weekly fluctuation of important waterfowl species in the Stillwater Creek Watershed from August 29, 1971 to April 22, 1972

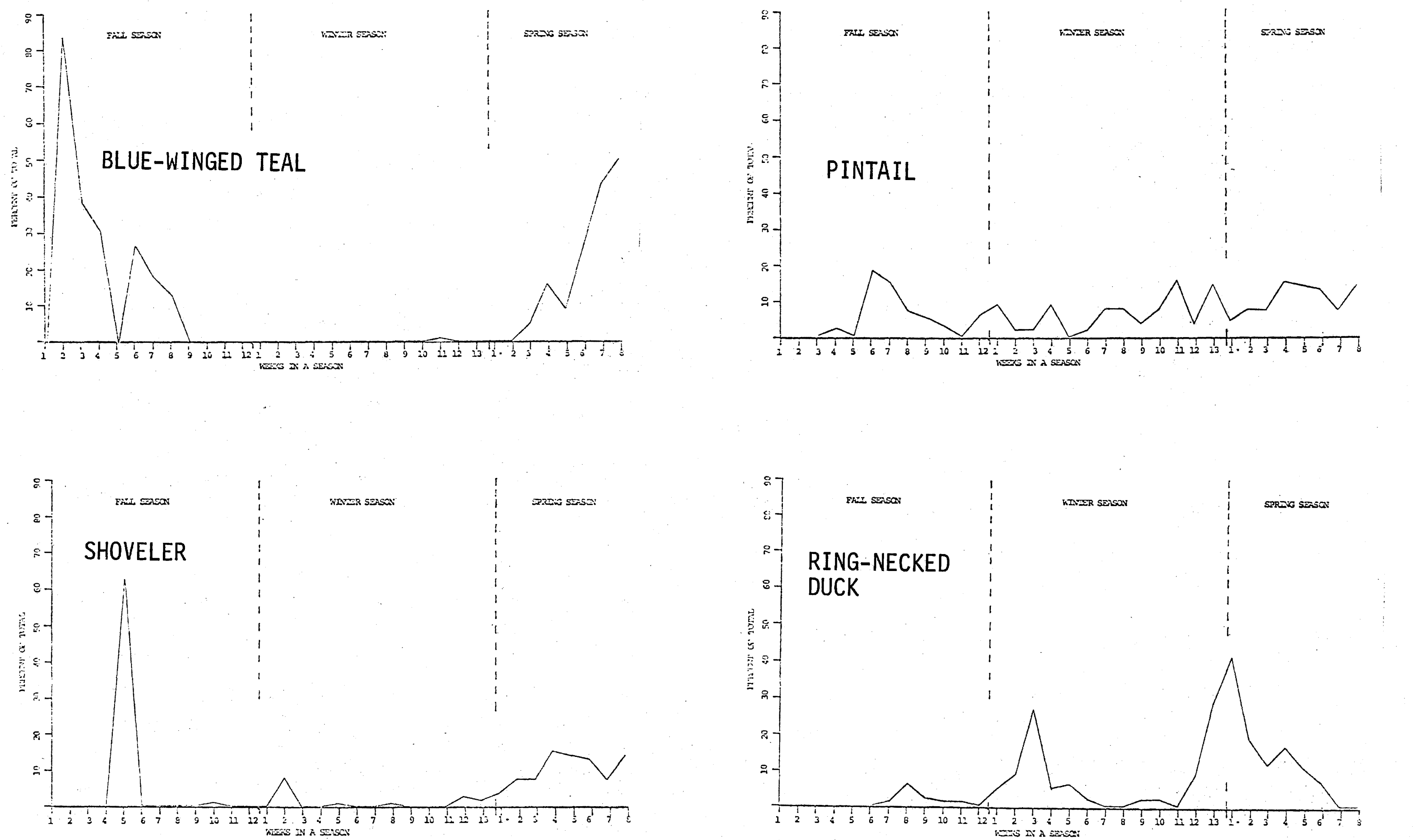


Fig. 13. (Continued)

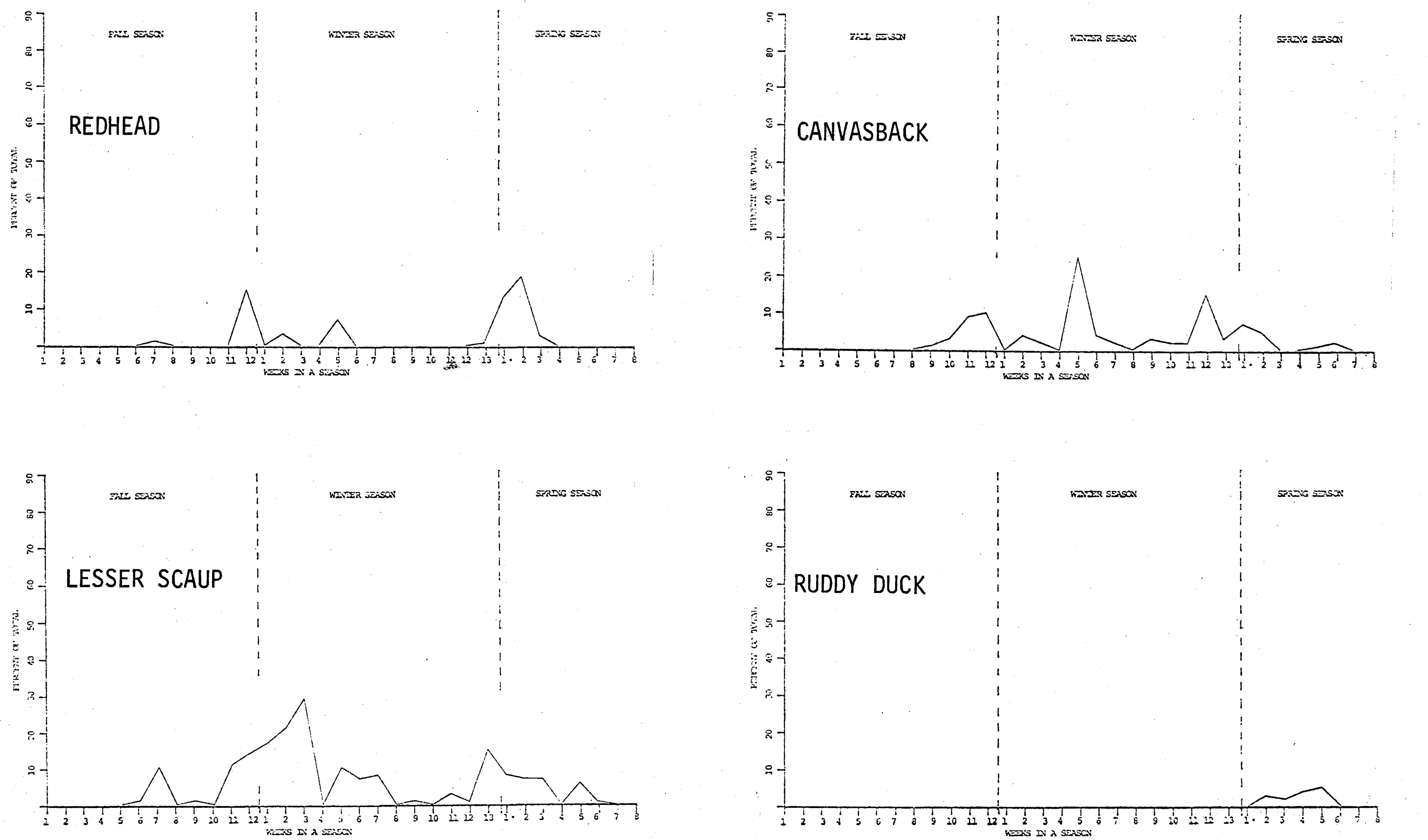


Fig. 13. (Continued)

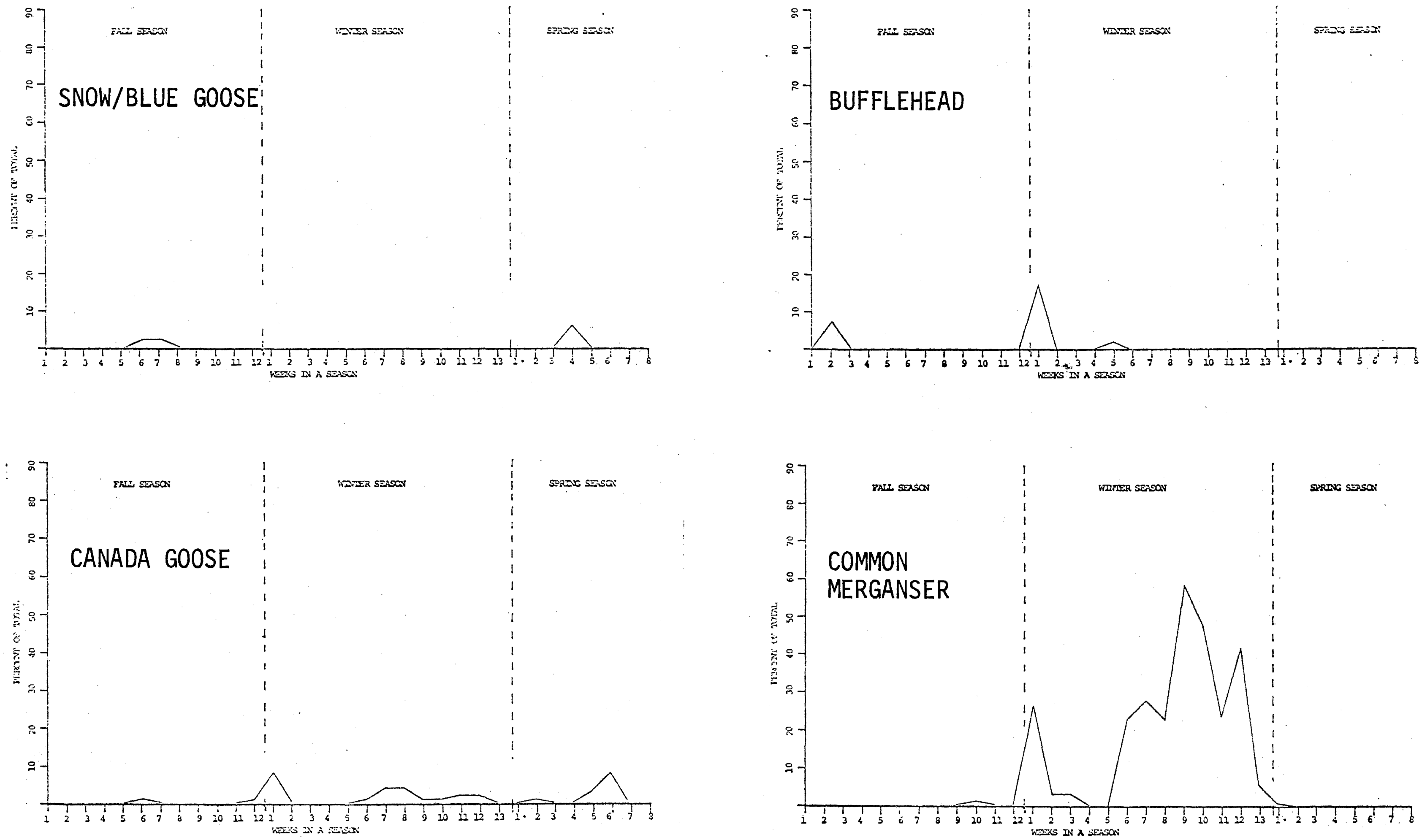


Fig. 13. (Continued)

The second and third weeks of the winter season brought in the first major flights of mallard and common merganser which dominated this early winter build-up. A rapid decline in waterfowl numbers was observed on the fourth week of winter (December 19-25, 1971) and coincided with the opening of the second-half of Oklahoma's waterfowl hunting season. The largest build-up occurred during the ninth and tenth week of the winter season (January 23 - February 5, 1972). Dominant species included the mallard and common merganser. The spring migration reached a peak during the first week (February 27 - March 4, 1972) of the season with a gradual decline thereafter. Blue- and green-winged teal dominated the latter weeks of the spring migration. Figure 13 illustrates the weekly fluctuations of each important waterfowl species observed using impoundments in the Stillwater Creek Watershed.

Fall Migration (August 29 - November 27, 1971)

An average of 52 waterfowl per observation, representing over 16 species, were counted during the fall migration (Table X). Dominant waterfowl species included wigeon, gadwall, blue- and green-winged teal. Combined, they accounted for over 70 percent of the total number of waterfowl observed. Weekly fluctuations for these species (Fig. 13) shows that their percent of occurrence in the watershed is similar to that reported by others (Buller 1964, Metzen 1966, and Barstow 1957). The blue-winged teal was the earliest species to move through the watershed, reaching a peak during the second week (September 5-11, 1971) when over 80 percent of all waterfowl observed were blue-winged teal.

TABLE X

WATERFOWL OBSERVED IN THE STILLWATER CREEK WATERSHED
FROM AUGUST 29, 1971 TO NOVEMBER 27, 1971
(FALL MIGRATION)

| Species | Total Observed | Percent of Total |
|---|---|---|
| Wigeon | 7,997 | 27.19 |
| Gadwall | 6,537 | 22.22 |
| Green-winged Teal | 3,175 | 10.79 |
| Blue-winged Teal | 3,023 | 10.28 |
| Mallard | 2,849 | 9.68 |
| Pintail | 2,369 | 8.05 |
| Lesser Scaup | 1,408 | 4.79 |
| Redhead | 715 | 2.43 |
| Canvasback | 694 | 2.36 |
| Ring-necked Duck | 260 | 0.88 |
| Snow/Blue Goose | 225 | 0.76 |
| Shoveler | 51 | 0.17 |
| Common Merganser | 50 | 0.17 |
| Canada Goose | 40 | 0.14 |
| Bufflehead | 9 | 0.03 |
| Ruddy Duck | 8 | 0.03 |
| Miscellaneous Species | 7 | 0.02 |
| Total[a] | 29,415[b] | 100.00 |

[a]Total waterfowl counted in 563 observations
[b]Average number of waterfowl counted per observation is 52

The peak for green-winged teal was reached during the fourth week (September 19-25, 1971) when over 60 percent of the waterfowl observed were green-winged teal. Both species declined in numbers by the tenth week (October 31 - November 6, 1971) to less than 10 percent of the total.

Wigeon and gadwall were important species during the fall migration, together contributing over 49 percent to the total number of waterfowl observed. Gadwall numbers reached a seasonal peak on the tenth week (October 31 - November 6, 1971) amounting to almost 50 percent of all waterfowl observed that week. Wigeon numbers peaked during the eighth week (Oct. 17-23, 1971) representing over 40 percent of all waterfowl observed that week.

Mallard numbers reached a seasonal high during the twelth week (Nov. 14-20, 1971), representing 30 percent of all waterfowl observed that week. Pintail numbers, contributing only 8 percent to the seasonal total, were a significant portion (over 20 percent) of all waterfowl observed during the ninth week (Oct. 3-9, 1971) of the fall season. The remaining species listed in Table X are not considered dominant fall migrants since their numbers contributed only a small percent to the total number of waterfowl observed.

The migration chronology of individual waterfowl species passing through the watershed during the fall season was similar to that described by Kortright (1953), Rue (1973), and Robbins et al. (1966). Flights were massed, quickly reaching peak numbers with a rapid decline as the season progressed. The early migrants - teal, gadwall, and wigeon - began to appear in the watershed by early September. First to appear and move through were the teal, followed by wigeon and then gadwall. Both species of teal and the gadwall migrated quickly through the watershed. The more lingering migration pattern of the wigeon may explain its seasonal dominance. From these data it appears that Stillwater Creek Watershed provides primarily migratory rather than wintering habitat for these species.

TABLE XI

WATERFOWL OBSERVED IN THE STILLWATER CREEK WATERSHED
FROM NOVEMBER 28, 1971 TO FEBRUARY 26, 1972
(WINTERING PERIOD)

| Species | Total Observed | Percent of Total |
|---|---|---|
| Mallard | 22,516 | 34.75 |
| Common Merganser | 19,936 | 30.76 |
| Pintail | 4,675 | 7.21 |
| Lesser Scaup | 4,277 | 6.60 |
| Ring-necked Duck | 3,314 | 5.11 |
| Gadwall | 2,234 | 3.45 |
| Green-winged Teal | 2,188 | 3.38 |
| Canvasback | 2,102 | 3.24 |
| Wigeon | 970 | 1.50 |
| Canada Goose | 874 | 1.35 |
| Shoveler | 831 | 1.28 |
| Redhead | 328 | 0.51 |
| Bufflehead | 206 | 0.32 |
| Hooded Merganser | 175 | 0.27 |
| Goldeneye | 80 | 0.12 |
| Blue-winged Teal | 45 | 0.07 |
| White-fronted Goose | 35 | 0.05 |
| Miscellaneous Species | 17 | 0.03 |
| Wood Duck | 7 | 0.01 |
| Ruddy Duck | 2 | (tr) |
| Black Duck | 2 | (tr) |
| Total[a] | 64,814[b] | 100.00 |

[a]Total waterfowl counted in 674 observations
[b]Average number of waterfowl counted per observation is 96

Wintering Season (November 28, 1971 - February 26, 1972)

An average of 96 waterfowl per observation, representing over 21 species, were counted during the wintering period (Table XI). Dominant waterfowl species were mallard and common merganser, accounting for over 65 percent of the total number of waterfowl observed. Mallard numbers, which peaked at 70 percent during the fourth week (Dec. 19-25, 1971), contributed over 34 percent to the total number of waterfowl observed for the winter season. Mallard dominance was especially significant from the fourth to the eleventh week, averaging over 50 percent of all waterfowl observed. The last two weeks of the wintering period showed a gradual decline in mallard numbers to less than 10 percent of the total during the thirteenth week (Feb. 20-26, 1972).

The common merganser was an important species during the wintering period representing over 30 percent of all waterfowl observed (Table XI). Common merganser numbers reached a peak during the ninth week (Jan. 23-29, 1972) when over 60 percent of all waterfowl observed were of this species. Duration of dominance, while not as long as that of the mallard, was characteristic of a wintering chronology in contrast to the rapid flights of the fall migration. The waning of common merganser dominance occurred during the thirteenth week (Feb. 20-26, 1972) when their presence accounted for less than 10 percent of all waterfowl observed.

Waterfowl species of less importance during the wintering period were pintail, lesser scaup, and ring-necked duck. Pintail numbers fluctuated from week to week, reaching a high of 15 percent during the eleventh week (Feb. 6-12, 1972). Lesser scaup and the ring-necked duck, each peaking at 30 percent of the total during the third week (Dec. 12-18, 1971), are characteristic of migrants passing through the watershed rather than wintering species. The canvasback, while only contributing 3 percent to the seasonal total, was an important species during the fifth week (Dec. 26, 1971 - Jan. 1, 1972) when its numbers accounted for 25 percent of all species observed. All other species observed during the winter period contributed only 10 percent to the total number observed.

Except for the common merganser, which was significantly more dominant, percent of occurrence for the species observed during the winter was similar to that reported by Buller (1964), Metzen (1966), and Barstow (1957). The common merganser is a bird of large, warm-water impoundments (Kortright 1953 and Rue 1973) which has taken advantage of large reservoirs constructed in Oklahoma and Kansas (Miller 1973). Two important wintering areas for the common merganser in the Stillwater Creek Watershed are Lakes Carl Blackwell and McMurtry. Large numbers of common mergansers, especially on Lake Blackwell, were the greatest contributing factor to this species seasonal dominance in the watershed.

Wintering chronology for individual species observed in the watershed during the winter was similar to that described by Kortright (1953), Rue (1973), and Robbins et al. (1966). The mallard is typically a late southward migrant, wintering as far north as conditions permit. Common mergansers are also late migrants, wintering on large reservoirs. The Stillwater Creek Watershed is primarily used as wintering habitat for these two species. Lesser scaup and ring-necked ducks are late fall - early winter migrants, utilizing the watershed for migration rather than wintering habitat. In contrast to the fall migration, the wintering of the mallard and the common merganser is of long duration without the rapid population build-up and decline, characteristic of fall migrants.

The largest build-up of waterfowl during the entire study period occurred during the tenth week (Jan. 30 - Feb. 5, 1972) of the winter season when an average of over 500 waterfowl were counted per observation.

Spring Migration (February 27 - May 22, 1972)

During the spring migration, an average of 46 waterfowl, representing over 18 species, were counted per observation (Table XII). The spring migration was not characterized, as in the fall, by the dominance of a relatively few species. In contrast to the fall, when 70 percent of all observed waterfowl were comprised of four species, seven species contributed to over 70 percent of all waterfowl observed during the spring migration. The most frequently observed waterfowl was the ring-necked duck, contributing 23 percent to the seasonal total, followed by the pintail (12 percent), green-winged teal (11 percent), blue-winged teal, redhead and shoveler (9 percent each), and wigeon (7 percent).

Ring-necked duck numbers increased during the last weeks of winter, reaching a peak during the first week of the spring season, (Feb. 27 - March 4, 1972), and accounting for over 40 percent of all waterfowl observed that week. Green-winged teal dominance increased during the spring season, reaching a peak of 25 per cent of the total during

TABLE XII

WATERFOWL OBSERVED IN THE STILLWATER CREEK WATERSHED
FROM FEBRUARY 27, 1972 TO MAY 22, 1972
(SPRING MIGRATION)

| Species | Total Observed | Percent of Total |
|---|---|---|
| Ring-necked Duck | 5,433 | 22.81 |
| Pintail | 2,770 | 11.63 |
| Green-winged Teal | 2,731 | 11.46 |
| Blue-winged Teal | 2,100 | 8.82 |
| Redhead | 2,093 | 8.79 |
| Shoveler | 2,031 | 8.53 |
| Wigeon | 1,625 | 6.82 |
| Gadwall | 1,345 | 5.65 |
| Lesser Scaup | 1,275 | 5.35 |
| Canvasback | 922 | 3.87 |
| Mallard | 800 | 3.36 |
| Ruddy Duck | 364 | 1.53 |
| Snow/Blue Goose | 115 | 0.48 |
| Canada Goose | 91 | 0.38 |
| Common Merganser | 82 | 0.34 |
| Bufflehead | 28 | 0.12 |
| Miscellaneous Species | 9 | 0.04 |
| White-fronted Goose | 7 | 0.03 |
| Total[a] | 23,821[b] | 100.00 |

[a]Total waterfowl counted in 520 observations
[b]Average number of waterfowl counted per observation is 46

the seventh week (April 9-15, 1972). The blue-winged teal was the most frequently observed waterfowl during the eighth week (April 16-22, 1972) contributing over 50 percent to all waterfowl observed that week. Redhead numbers reached a seasonal high during the second week (March 5-11, 1972) when over 20 percent of all waterfowl observed were redheads. Shoveler numbers began to increase during the spring migration reaching a high of 20 percent of the total during the fourth week (March 19-25, 1972). The wigeon reached a weekly peak of 20 percent during the seventh week (April 9-15, 1972) of the spring season.

Migration chronology for individual species passing through the watershed during the spring was similar to that reported in the literature (Buller 1964, Metzen 1966, Kortright 1953, and Rue 1974). Both the green- and blue-winged teal were dominant species during the latter weeks of the season. The ring-necked duck was the dominant species during the early spring, declining rapidly by the third week. The pintail maintained a relatively low dominance throughout the season. Wigeon and gadwall numbers did not reach the high peaks associated with these species during the fall migration. Their presence in the watershed during the spring was more uniform than in the fall.

Spring migration through the watershed was characterized as one of leisure without the wave or massing flights typical of the fall migration. Mallards and common mergansers, dominant wintering species, began their northward migration prior to the beginning of the spring season.

Stillwater Creek Watershed provides primarily fall and spring migration habitat for most species while supplying wintering habitat for the mallard and common merganser.

Nesting Season (May 28 - August 27, 1972)

A rigorous examination of 384 censused impoundments was conducted during the first three weeks of June (1972) in search of nesting waterfowl. This survey revealed the nesting of two McGraw mallards, with the subsequent hatching of two broods, and a female wood duck with a brood of seven ducklings. The mallards were located on an intensively managed impoundment where they have previously reared young (Allen 1975). The wood duck brood was located in an undisturbed area of Ham's Lake (Fig. 11) characteristic of wood duck nesting habitat. These two cases were the only known nesting to occur in the watershed.

Previous waterfowl nesting information is very sketchy for the watershed. A few landownders indicated that teal may have reared young on farm ponds although there are no recently published data identifying nesting waterfowl in the Stillwater Creek Watershed. The nesting survey revealed that the watershed has not been an important area for waterfowl nesting.

## Evaluation of Habitat Characteristics

Two-way classifications of Analysis of Variance (AOV) were computed for each of the Static and Dynamic habitat characteristics intensively surveyed for 100 impoundments and associated watersheds (Table V and VI). A statistically significant (distribution of "F" at 10% and 25%) difference in the waterfowl-use index (NWFL) was noted for 8 of the 19 Static and 4 of the 5 Dynamic characteristics (Table XIII). Appendix D presents all of the computed AOV tables with their corresponding mean NWFL values and AOV cell means for each category.

TABLE XIII

RESULTS OF STATISTICAL AOV'S FOR STATIC AND DYNAMIC HABITAT CHARACTERISTICS

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NWFL Significantly (P $<$.10) Different Due to:

Size
Orientation of the Dam
Shoreline Development Index
Maximum Depth-Surface Relation
Distance to Section Road
Distance to Major Impoundment
Ownership
Alkalinity

NWFL Significantly (P $<$.25) Different Due to:

Surrounding Topography
Aquatic Vegetation Index
Macroinvertebrate Abundance
Water Level

NWFL Not Significantly Different Due to:

Visibility from Roadway
Land Use of Watershed
Extent of Livestock Grazing
Erosion Conditions
Cattle Activity at Edge
Distance to Major Food Crops
Distance to Human Dwellings
Degree of Habitat Management
Extent of Human Disturbance
Degree of Land Posting
Presence of Exposed Shoreline
Turbidity

---

## Seasonal Effect

All AOV's showed a significant difference in NWFL due to a seasonal effect (Fig. 14). Calculation of "F" test indicates that there is a significant ($p < .10$) difference in NWFL due to the season of the year. The fall NWFL mean was 0.99 - an average of approximately one waterfowl per surface acre for each observation. During the winter season, the NWFL increased to about 3, with the spring migration averaging almost 4 waterfowl per surface acre for each observation. The difference in seasonal NWFL means reflects an overall difference in habitat selection from fall to spring resulting in an increased preference for smaller impoundments during the spring. The basis for this preference reflects the difference in Static and Dynamic habitat characteristics. The seasonal effect on NWFL corresponds to the chronology of migration in the watershed. Fall movements were rapid and concentrated on the larger impoundments. The winter season was dominated by two species, mallard and common merganser, with mallards selecting the smaller impoundments during daylight hours. Spring waterfowl movements were slow and lingering with waterfowl preferring the smaller bodies of water.

The seasonal effect is the most readily identifiable outcome of differing habitat preference patterns. Patterns of selection for each Static and Dynamic habitat characteristic are discussed in detail below.

## Static Characteristics

Statistical results and a discussion of the relevance of 19 Static habitat characteristics to waterfowl use of impoundments are as follows:

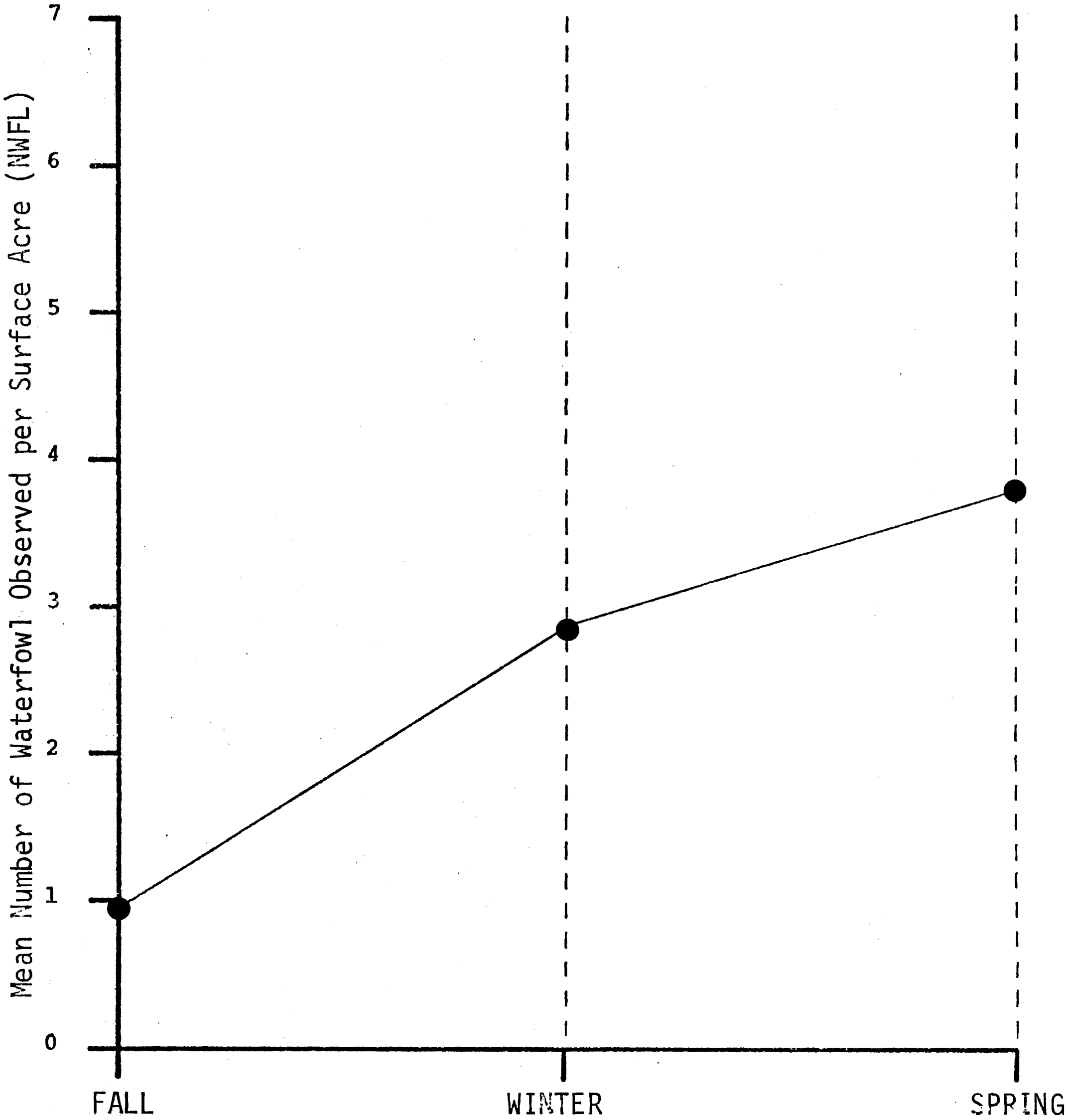


Fig. 14. Comparison of seasonal means for effect due to season

<u>Impoundment Size</u>. Statistical AOV shows there is a significant ($p < .10$) difference in NWFL due to the size of an impoundment (Appendix D, p. 145). The seasonal mean NWFL for each size category indicates that waterfowl preferred the smaller impoundments (0.0405 - 0.405 ha.) during the winter and spring (Fig. 15). During the fall migration, NWFL was approximately the same for all size categories, while the wintering and spring periods showed an increase in the use of the smaller impoundments. No waterfowl were observed using the three impoundments in the third category (4.06 - 40.50 ha.). Lack of preference for the smaller impoundments during the fall migration may be due to hunting pressure which tends to force birds to the larger impoundments that provide shelter and safety. The dominant form of waterfowl hunting in the watershed is "pond jumping"; a method whereby the hunter approaches the blind side of an impoundment in hopes of "jumping" waterfowl as they come into view. It is believed that this form of hunting keeps birds together on the larger impoundments where they are protected from this hunting technique.

Factors contributing to the spring preference of smaller impoundments include food availability and spring courtship behavior of waterfowl. Generally, the smaller the impoundment the earlier the aquatic vegetation and associated macrophytes become available. This is due to the increased heat budget of a smaller lake and the greater percentage of coverage in the euphotic zone (Ruttner 1963). Kortright (1953) and others indicate that waterfowl may begin to form pair bonds during late winter and early spring and that mated pairs may, depending on habitat conditions, establish a territory. This territoriality may have been a functioning factor in the SCW during the spring migration

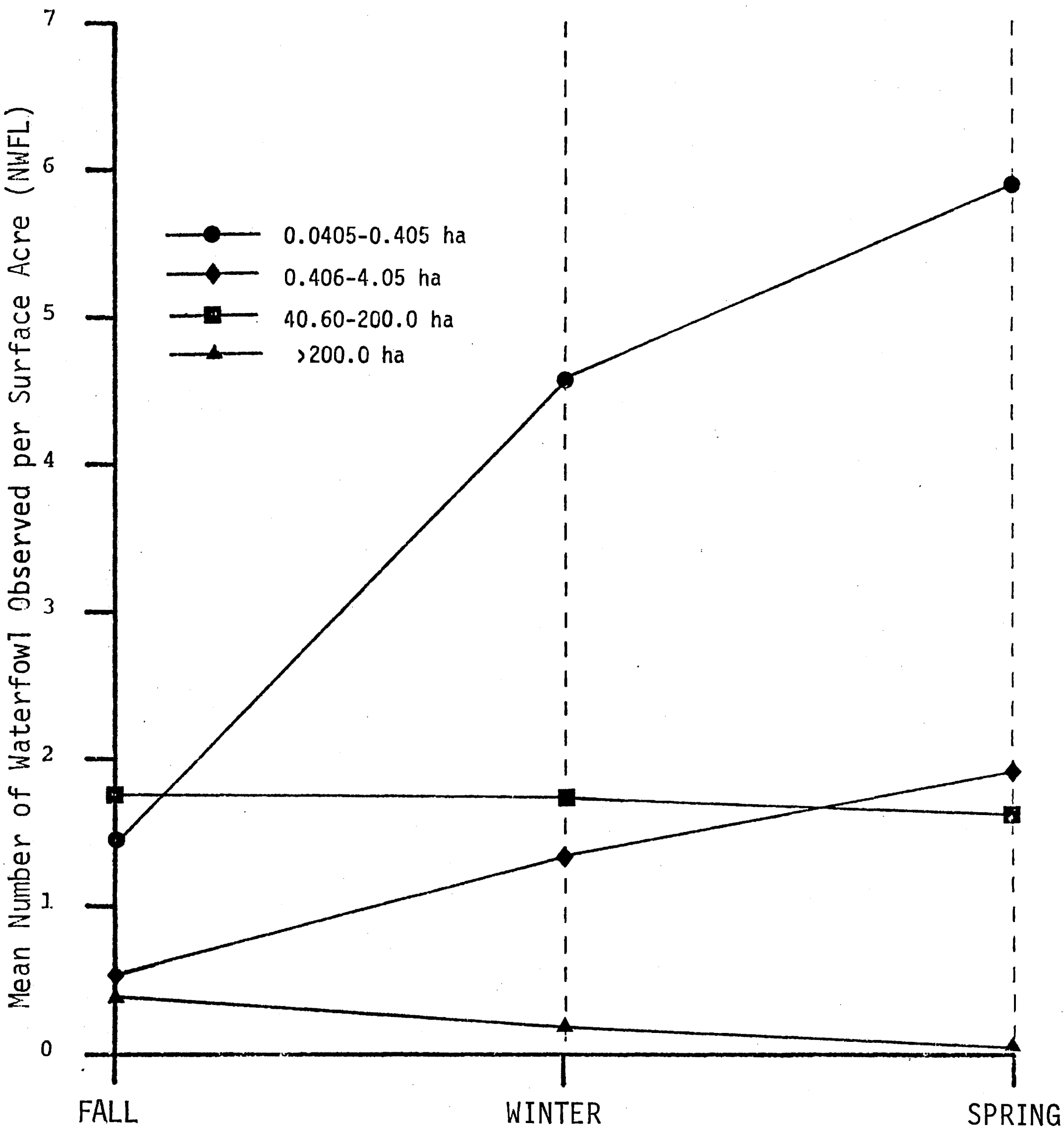


Fig. 15. Comparison of seasonal means for effect due to impoundment size

causing mated pairs to seek the more isolated, smaller impoundments.

The combination of migration chronology, hunting pressure, food availability, and courtship behavior may explain the significant seasonal differences in the use of smaller impoundments. A test for seasonal x size category interaction reveals that there is no interaction at $p < .25$. The test for interaction is used to determine the relationship between the effects of factors (Snedecor and Cochran 1967). The test answers the question: Is the effect of A (size category) the same at the other levels of B (seasons).

Orientation of Dam. Analysis of variance indicates a significant ($p < .10$) difference in NWFL due to the orientation of the dam (Appendix D, p. 146). Overall means show that impoundments with southward and westward facing dams were preferred to others (Fig. 16). This preference pattern corresponds to seasonal wind directions in the watershed. The dominant winds are from the south-southwest, particularly during the winter and spring seasons. Preference for south-southwest dams is highest during these seasons, supporting the hypothesis that waterfowl seek habitat that offers protection from strong winds. The lack of dominance by any one compass orientation during the fall migration may be explained by migration chronology. Fall movements are rapid, wave-like motions of waterfowl, moving out of the watershed ahead of major weather fronts which are usually accompanied by strong northerly winds. It was expected that impoundments with northward facing dams would be preferred during the fall; however, this was not the case. During the fall, when strong winds were from the north, most waterfowl moved out of the watershed. After passage of the front, followed by a new wave of waterfowl, the winds, usually from the south,

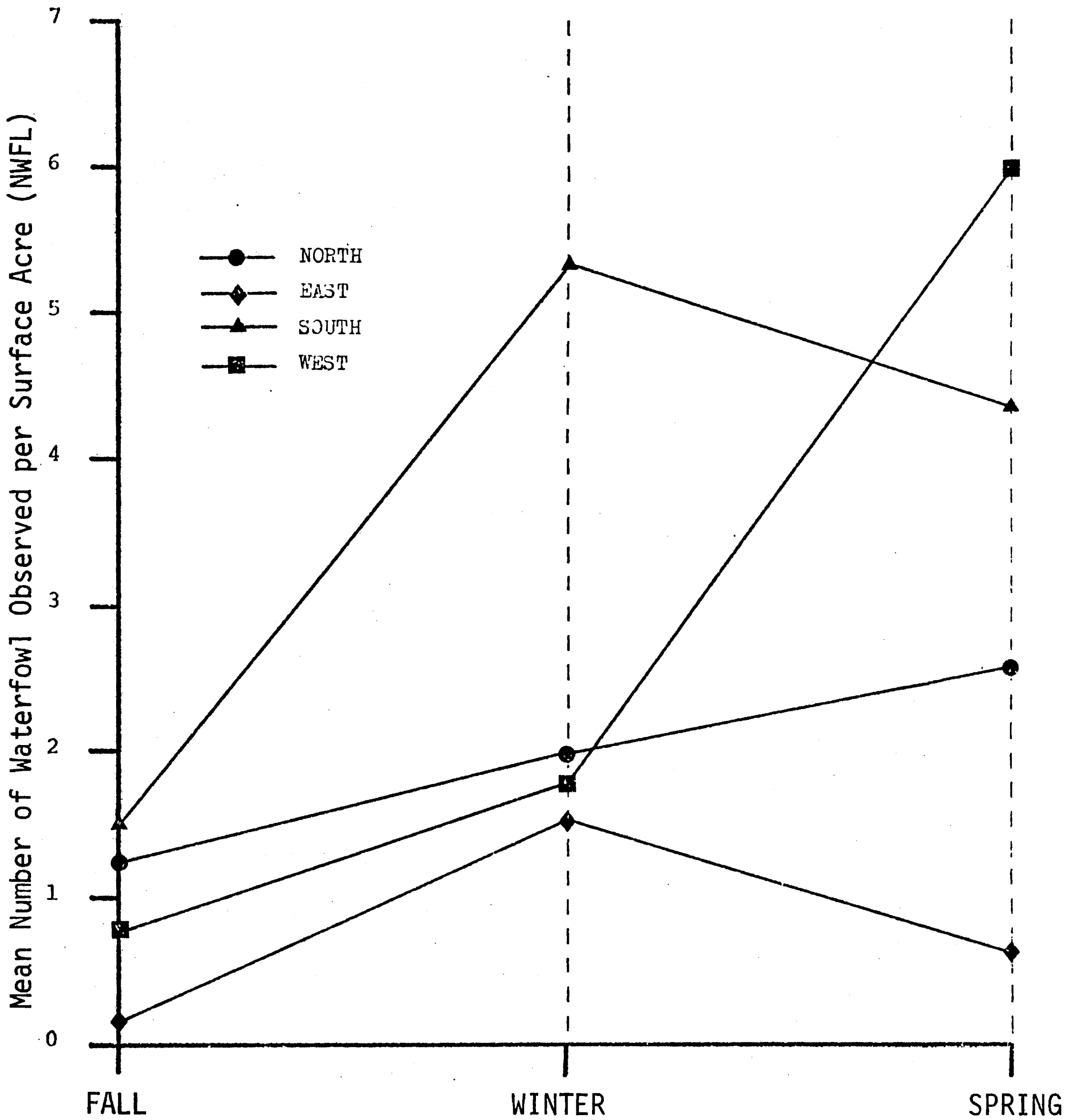


Fig. 16. Comparison of seasonal means for effect due to dam orientation

were of such low velocity that dam orientation had little effect on habitat selection. Selection of south and westward facing dams during the winter and spring season, characterized by lingering movements of waterfowl and dominated by strong south-southwest winds, follows the expected pattern.

A test for seasonal use x dam orientation interaction shows no interaction at the $p < .25$ significance level. Tests for interaction for dam orientation x wind-chill index and dam orientation x wind direction shows that at $p < .25$ the effect of dam orientation on habitat selection is influenced by wind direction, speed, and air temperature. This supports the hypothesis that waterfowl prefer habitat which provides protection from cold, strong winds.

Visibility from Roadway. Statistical AOV indicates no significant ($p < .25$) difference in NWFL due to impoundment visibility from a roadway (Appendix D, p. 147). Overall NWFL means for each category reveals little difference. It was hypothesized that impoundments which could not be seen from a roadway would be preferred, particularly during the fall migration when hunting pressure affects habitat selection.

The lack of significance may be due to migration chronology which reveals that waterfowl generally avoided the smaller impoundments during the fall migration. During the spring, when smaller impoundments were preferred, visibility from a roadway has little effect on habitat selection, perhaps due to the absence of hunting pressure. A test for visibility x season interaction reveals no interaction at the $p < .25$ level.

Land use of Watershed. Statistical AOV shows no significant ($p < .25$) difference in NWFL due to the land use pattern of the surveyed watersheds (Appendix D, p. 148). Comparison of overall NWFL means shows little difference among the land use categories except for the "Oil Field" category which showed no waterfowl use. Land surrounding an oil field is usually severly eroded, lacks vegetation, is heavily silted, often resulting in, or a consequence of, saline conditions.

Lack of significance for land use patterns was unexpected. It was believed that land classified as "Idle" would be preferred over other land use categories. Although there is no statistical difference, comparison of seasonal means shows a higher fall mean NWFL for the "Idle" category. An idle or non-consumptive watershed land use pattern usually gives rise to a clear, productive impoundment. However, the spring NWFL mean for the "Idle" category was the lowest of all categories, indicating a change in preference patterns. During the winter season, watersheds supporting crops recorded a higher mean NWFL than other categories. It was during this period that large numbers of mallards were observed spending morning and evening hours feeding on winter wheat and maize. The spring decrease in the mean NWFL for the "Idle" category may be due to increases by all other categories.

Watersheds near human dwellings show low NWFL means for fall and winter due to associated disturbance factors which are more effective during these seasons. However, the mean NWFL for the "Human Habitation" category increased during the spring; the absence of hunting and the less wary nature of waterfowl perhaps contributing to the increase. For example, during the fall both the green- and blue-winged teal avoided impoundments located near human dwellings. However, during the spring, it was not uncommon to observe a pair of teal using an impoundment within the immediate area of farm buildings and livestock, apparently undisturbed by the nearby habitation.

Test for interaction ($p < .25$) indicates that the mean NWFL for each land use category was not influenced by the seasonal means.

Surrounding Topography. There was a significant difference ($p < .25$) in NWFL due to the surrounding topography of an impoundments' watershed (Appendix D, p. 149). Comparison of overall means shows that "Semi-closed" impoundments were preferred during the winter and spring seasons. Impoundments in this category are located in slight depressions, usually 50 percent surrounded by shoreline vegetation, and not easily visible from a roadway. The presence of vegetation along the banks provides cover and food.

Seasonal comparison of means for each category (Fig. 17) indicates that the dominance of "Semi-closed" impoundments increased during the winter with a slight decline in the spring. During the fall, the use of the more "Open" impoundments was less than that of the "Closed" category. Disturbance associated with hunting may explain the preference of "Closed" impoundments during the fall. The preference of the more open impoundments during the winter and spring supports the observed change in migration behavior. Habitat selection by spring migrants appeared to be based more on food availability and early courtship than on protection. Aquatic blooms usually occurred earlier in open impoundmnets due to the greater euphotic zone which in not affected by shoreline vegetation.

There is no significant ($p < .25$) interaction between seasonal effects and the effect due to surrounding topography.

Extent of Livestock Grazing. Analysis of Variance for the effect due to the extent of livestock grazing shows no significant difference

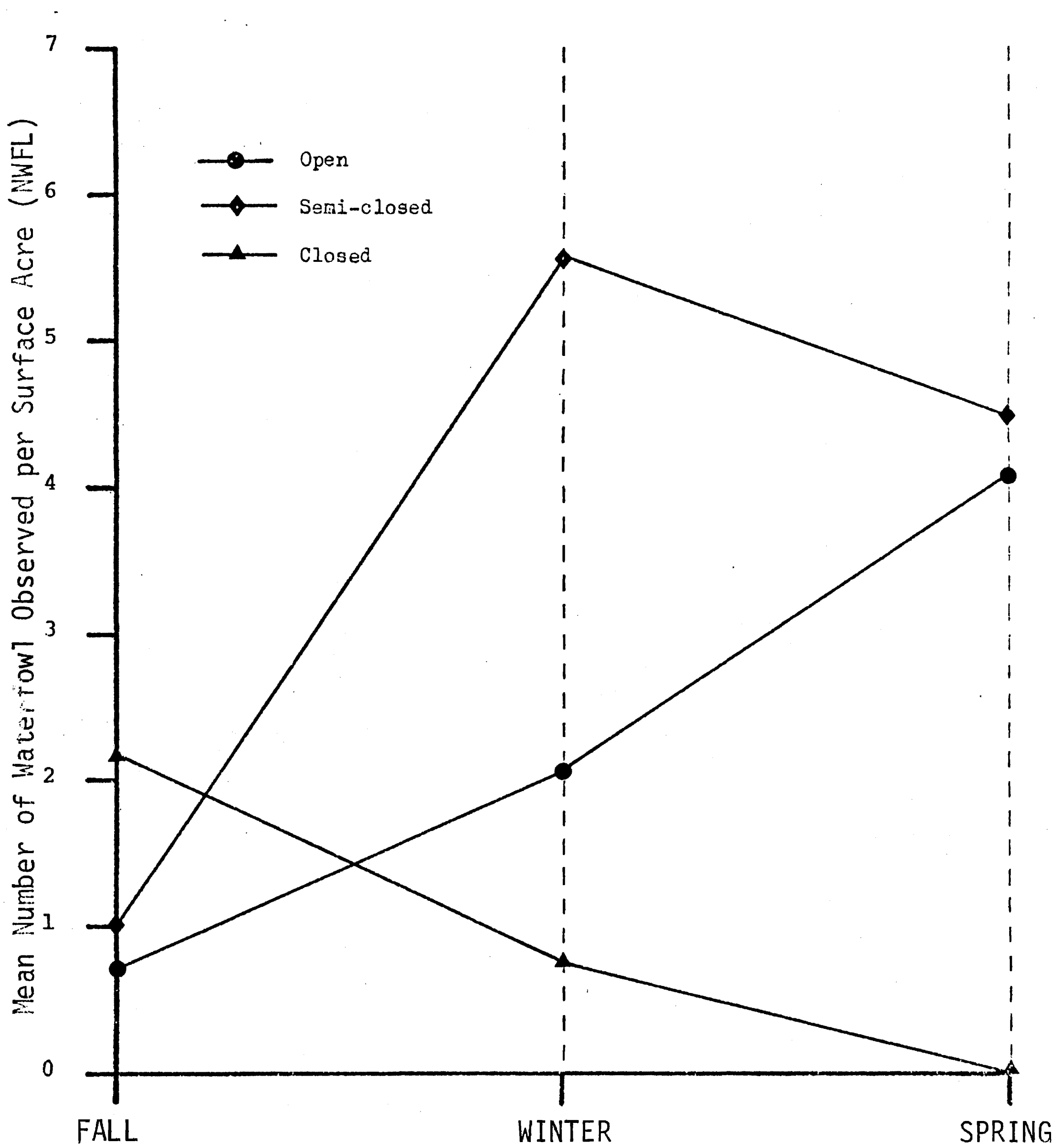


Fig. 17. Comparison of seasonal means for effect due to surrounding topography

in NWFL at $p < .25$ (Appendix D, p. 150). Although not significant, watersheds without grazing had a higher overall NWFL mean. It was hypothesized that the undergrazed watersheds, giving rise to clear, productive impoundments, would show a significantly higher mean NWFL. Comparison of seasonal means reveals that ungrazed watersheds show a greater use during the fall and spring migration, although not significantly greater than the "Overgrazed" watersheds.

A test for interaction at $p < .25$ indicates that the effects due to grazing conditions were not influenced by the season.

Erosion Conditions. Statistical AOV shows no significant ($p < .25$) difference in NWFL due to erosion conditions of the surveyed watersheds (Appendix D, p. 151). Comparison of overall NWFL means reveals that impoundments with non-eroded watersheds had a higher NWFL value than severly eroded watersheds. Although not significant, the trends shown by the means corresponds to the expected preference of the clearer, more productive ponds which are typically located in watersheds with little or no erosion. All erosion categories were utilized approximately the same degree during the fall migration.

No significant ($p < .25$) interaction between the seasonal effect and the effect due to the levels of erosion was determined.

Shoreline Development Index. AOV shows a significant ($p < .10$) difference in NWFL due to the degree of shoreline configuration (Appendix D, p. 152). Contrary to published data (Arner et al. 1970, Bue 1964, Cassel and Stewart 1969, and Trauger 1967) and what was anticipated, waterfowl in the Stillwater Creek Watershed preferred the less configured (i.e., more rounded) impoundments (Fig. 18). The basis for this unexpected pattern may be due to the nature of migration through

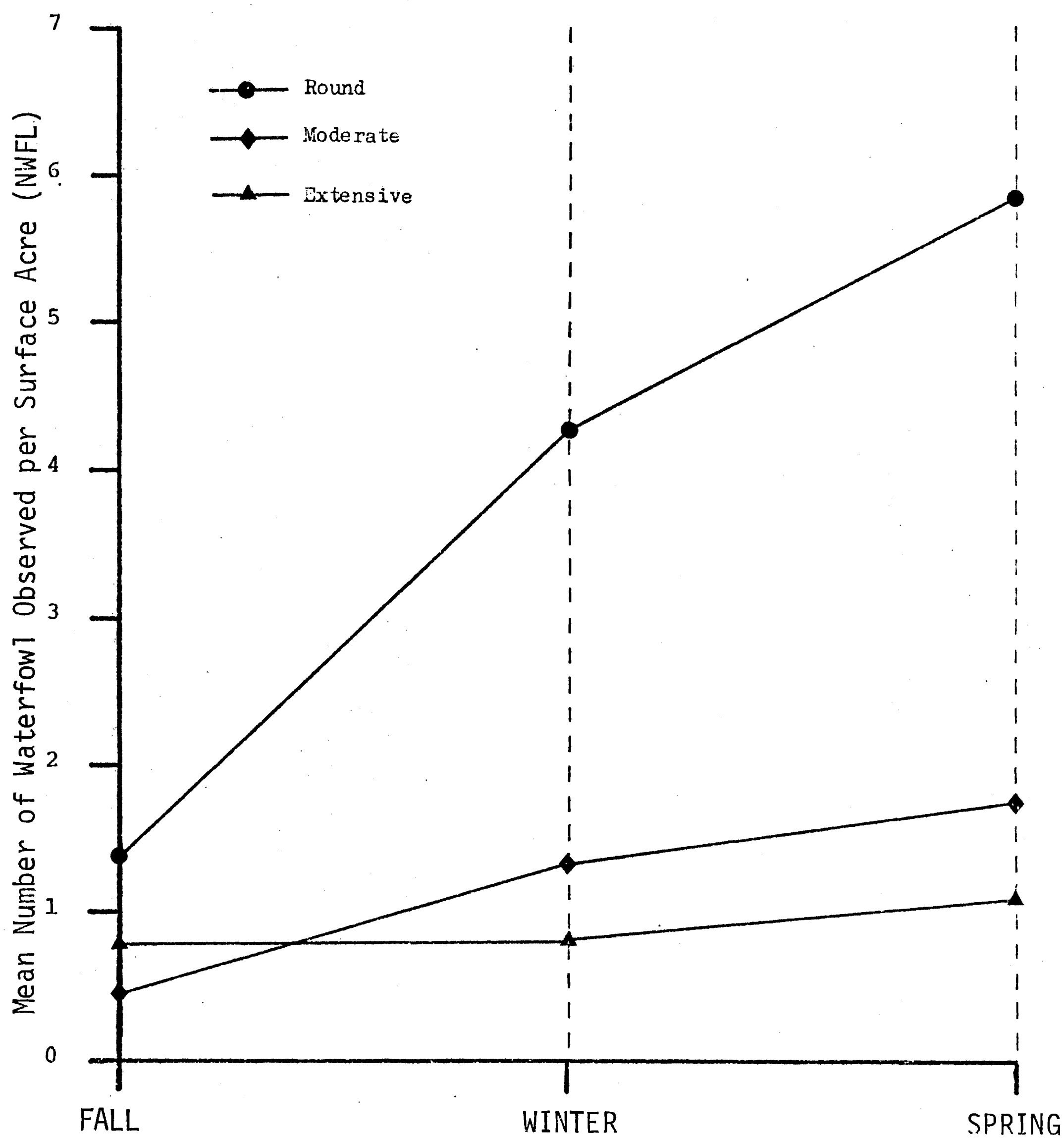


Fig. 18. Comparison of seasonal means for effect due to shoreline development index

the watershed. During the fall, movements are massed and quick, providing little time to seek out potentially favorable (i.e., configured impoundments) habitat. The dominance of "Round" impoundments during the winter and spring may be due to interacting factors. Most highly configured ponds are deeper, lacking a gradual slope which is conducive to early aquatic blooms. Additionally, the cover provided by a configured impoundment is apparently not critical during the spring migration, when waterfowl are less wary. The large number of small, round, and shallow farm ponds, in combination with the above mentioned factors,may have contributed to the lack of preference for configured impoundments.

No significant ($p < .25$) interaction between seasonal means and the effect due to the degree of shoreline configuration was observed.

<u>Maximum Depth - Surface Relation</u>. AOV shows a significant ($p < .10$) difference in NWFL due to the maximum depth - surface relation of an impoundment (Appendix D, p. 153). Comparison of seasonal means for each category (Fig. 19) reveals that during the winter and spring, waterfowl prefered impoundments with gradual slopes. These impoundments are usually the first to produce an aquatic bloom, and provide a greater amount of shallow (less than 45 cm.) water, essential for feeding dabblers. The lack of fall dominance by any one category is due to the nature of the fall migration when shallow, small impoundments are rejected for the larger impoundments which offer protection from hunting.

No significant ($p < .25$) interaction between the seasonal effect and the effect due to maximum depth - surface relation was observed.

<u>Cattle Activity at Edge</u>. No significant ($p < .25$) difference

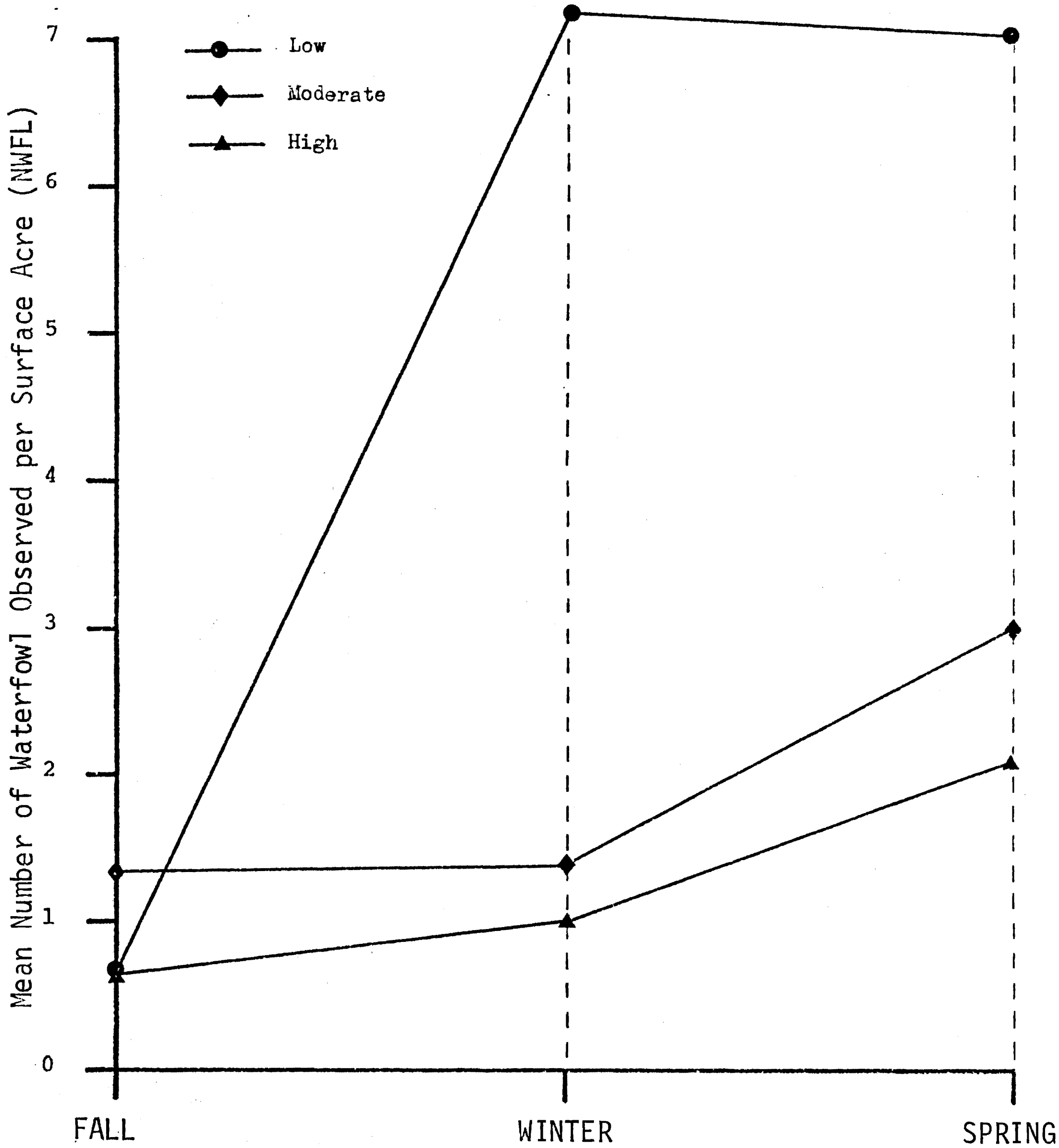


Fig. 19. Comparison of seasonal means for effect due to maximum depth-surface relation

in NWFL due to cattle activity at the edge of an impoundment was noted from the AOV (Appendix D, p. 154). Overall means indicate that the seasonal variation of each category follows the trend of migration behavior for waterfowl species in the watershed. During the fall migration, all categories received approximately the same amount of waterfowl use. Since cattle activity at the edge of an impoundment reduces shoreline vegetation and creates turbid conditions, it was believed that this type of habitat would be significantly rejected by waterfowl. Analysis shows that there was no significant rejection of any category. The insignificant increase in the "Light" category during the spring corresponds to the nature of the spring migration. Habitat selection by spring migrants, characterized by lingering movements and a wide dispersion of numbers, was not influenced by cattle activity at the edge of an impoundment.

Test for interaction reveals no significance at $p < .25$.

Distance to Major Food Crops. AOV shows that there was no significant ($p < .25$) difference in NWFL due to impoundment proximity to major food crops (Appendix D, p. 155). While not significant, the two closest categories (< 0.4 and 0.4 - 0.8 ha.) had a higher mean NWFL during the winter season. During the winter, mallards were commonly observed utilizing impoundments located near winter wheat and maize. Fall and spring migrants however, did not select habitat based on crop availability as evidenced by the narrow range in seasonal NWFL values for these seasons. The original hypothesis, preferred habitat would be near major food crops, may only function during the winter season. Spring and fall preference patterns for this Static characteristic indicates that habitat selection was not influenced by food crop availability. This can be explained by the nature of the fall and spring migration. Fall migrants were not in the watershed long enough to dominate impoundments located close to food crops. Spring migrants, preferring isolation, tended to disperse throughout the watershed, reducing the NWFL mean for impoundments located near food crops.

No significant ($p < .25$) interaction was observed between seasonal means and the mean NWFL for each distance category.

Distance to Human Dwellings. Analysis of Variance shows no significant ($p < .25$) difference in NWFL due to the proximity of human dwellings (Appendix D, p. 156). Fall means for each category are similar; spring means show an increase in the use of impoundments located between 0.8 and 1.6 km. away. It was hypothesized that the nearer an impoundment was to human dwellings the less likely it would be utilized by waterfowl. The non-significant increase in the 0.8 - 1.6 km. category during the spring may be due to isolation required by spring migrants.

Test for interaction between seasonal effect and effect due to impoundment proximity shows no significance at $p < .25$.

Distance to Section Road. Statistical analysis reveals a significant ($p < .10$) difference in NWFL due to the proximity of a section road (Appendix D, p. 157). Comparison of seasonal means (Fig. 20) reveals that the nearer an impoundment is located to a section road, the more use it receives. Dominance of the < 0.4 km. category increased during the study period reaching a peak during the spring. The preference of impoundments located near a section road is contrary to what was anticipated. It was believed that waterfowl would prefer the more isolated impoundments which would be located the greatest distance

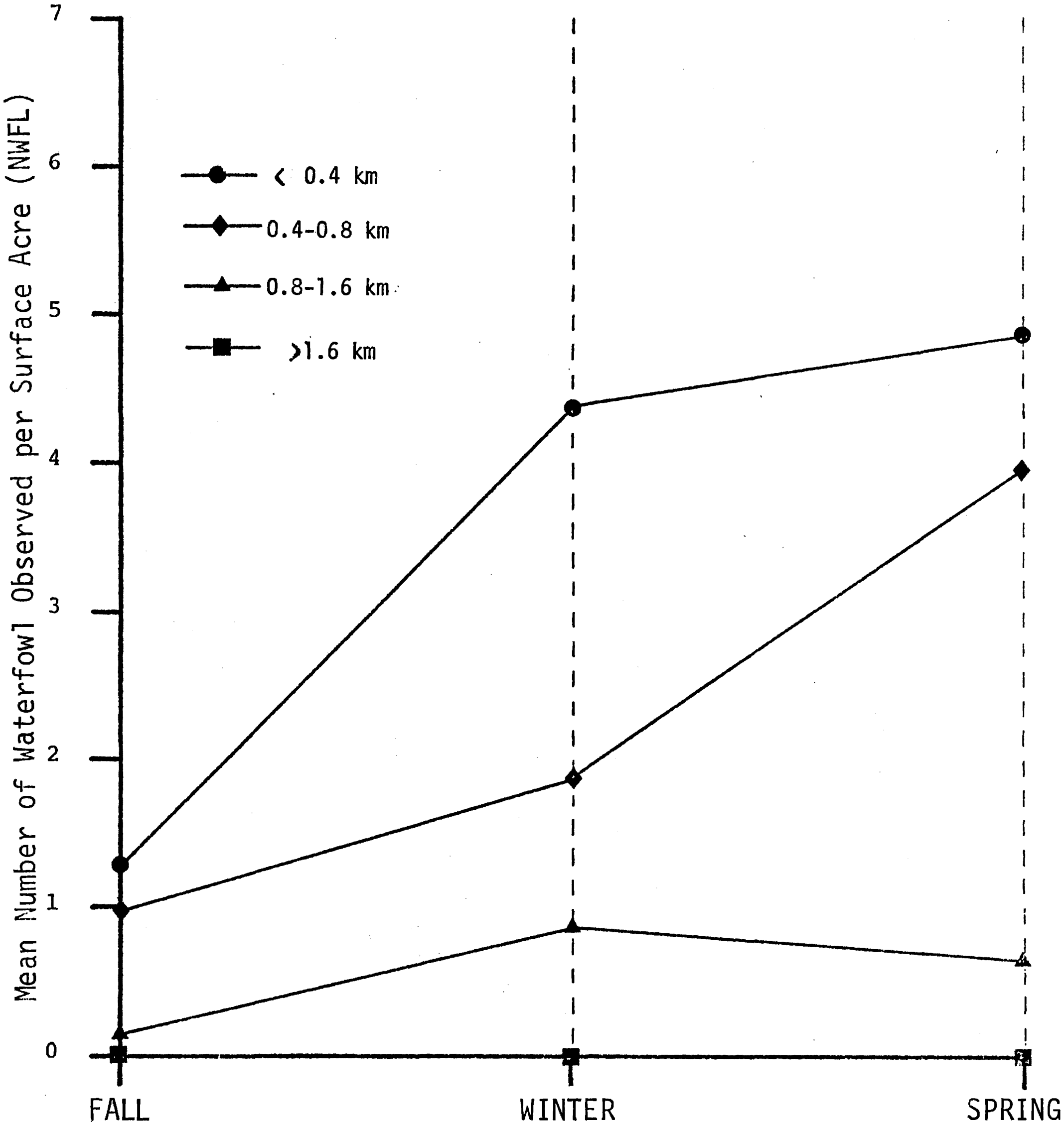


Fig. 20. Comparison of seasonal means for effect due to distance to a section road

from such disturbance factors as section roads. Results show, however, that spring migrants, being widely dispersed, may not be greatly affected by the disturbance associated with a nearby section road.

No significant ($p < .25$) interaction was noted between seasonal effect and effect due to section road proximity.

Distance to Major Impoundment. AOV indicates a significant ($p < .10$) difference in NWFL due to the proximity of a major impoundment - either Lake Blackwell, McMurtry, Ham's or Boomer (Appendix D, p. 158). Comparison of seasonal means (Fig. 21) shows that impoundments located from within 0.4 - 1.6 km. of the major impoundments were preferred during all seasons, reaching a peak during the spring. Data reveals that the major impoundments exert a zone of influence on the smaller impoundments located within a 1.6 km. radius. During the winter, a pattern of daily feeding flights to small, adjacent (0.4 - 1.6 km.) impoundments was noticed. Waterfowl left the major impoundments in the morning and returned by evening. The close proximity of category 1 ($<$0.4 km.) to a major impoundment may be responsible for its lack of preference.

During the spring, the zone of influence increased in distance to include impoundments located past the 1.6 km. zone. This corresponds to the dispersing nature of the spring migration. The fall preference for impoundments past the 1.6 km. radius was considerably less due to the non-dispersive pattern of the fall migrants.

No interaction ($p < .25$) was observed between seasonal effects and effect due to major impoundment proximity.

Ownership. Analysis of Variance shows a significant ($p < .25$)

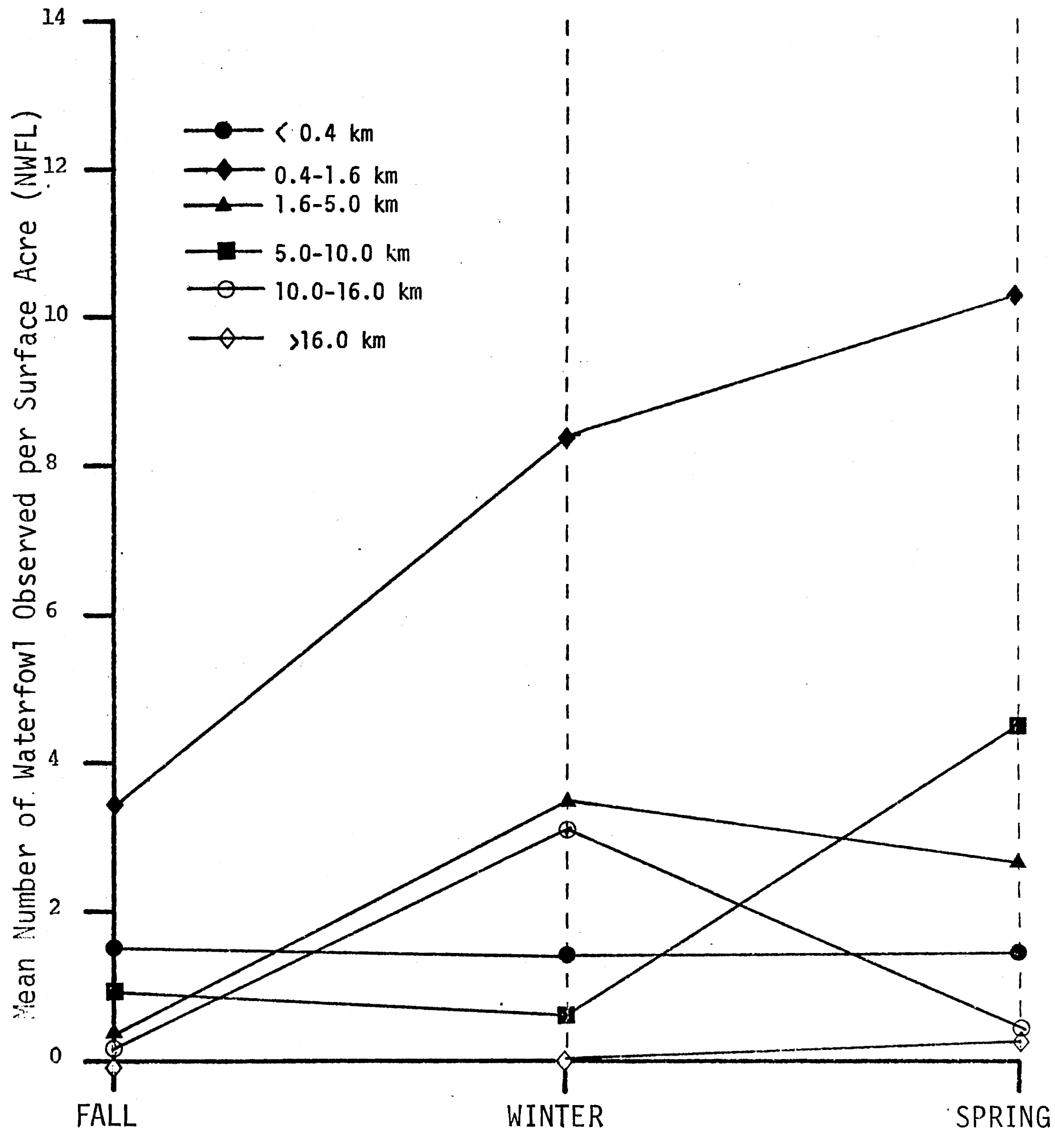


Fig. 21. Comparison of seasonal means for effect due to distance to a major impoundment

difference in NWFL due to ownership (Appendix D, p. 159). Comparison of seasonal means (Fig. 22) shows that "Government" owned (i.e., SCS) impoundments were not utilized as much as privately owned impoundments. Both ownership categories resulted in similar fall means, indicating that fall migrants were not selecting "Private" over "Government" owned habitat. As previously discussed, the fall migration is massed and rapid which does not provide waterfowl time to seek out preferred habitat. Spring migrants, due to their lingering movements, have ample opportunity to seek out preferred impoundments as evidenced by the significant difference in the spring means. Generally, SCS structures in the Stillwater Creek Watershed are not good quality waterfowl habitat. Landowner land use practices, structural design, and poor management, tend to make SCS impoundments a poor quality habitat. Two SCS structures which have been managed specifically for waterfowl, (Nos. 40 and 55), however, were utilized to a greater degree than other single purpose SCS impoundments.

No interaction ($p < .25$) was observed between the seasonal effect and effect due to ownership.

Degree of Habitat Management. AOV shows no significant ($p < .25$) difference in NWFL due to the degree of habitat management (Appendix D, p. 160). Comparison of seasonal means for each category reveals that the "Habitat Leased for Hunting/Management Techniques Used" was slightly more utilized during the fall than the other categories. This may be due to the attractiveness of the habitat as a result of management techniques. However, from a hunting standpoint, waterfowl use was not significantly greater. The increased use of the "Leased/No Management Techniques" category during the winter and spring indicates that

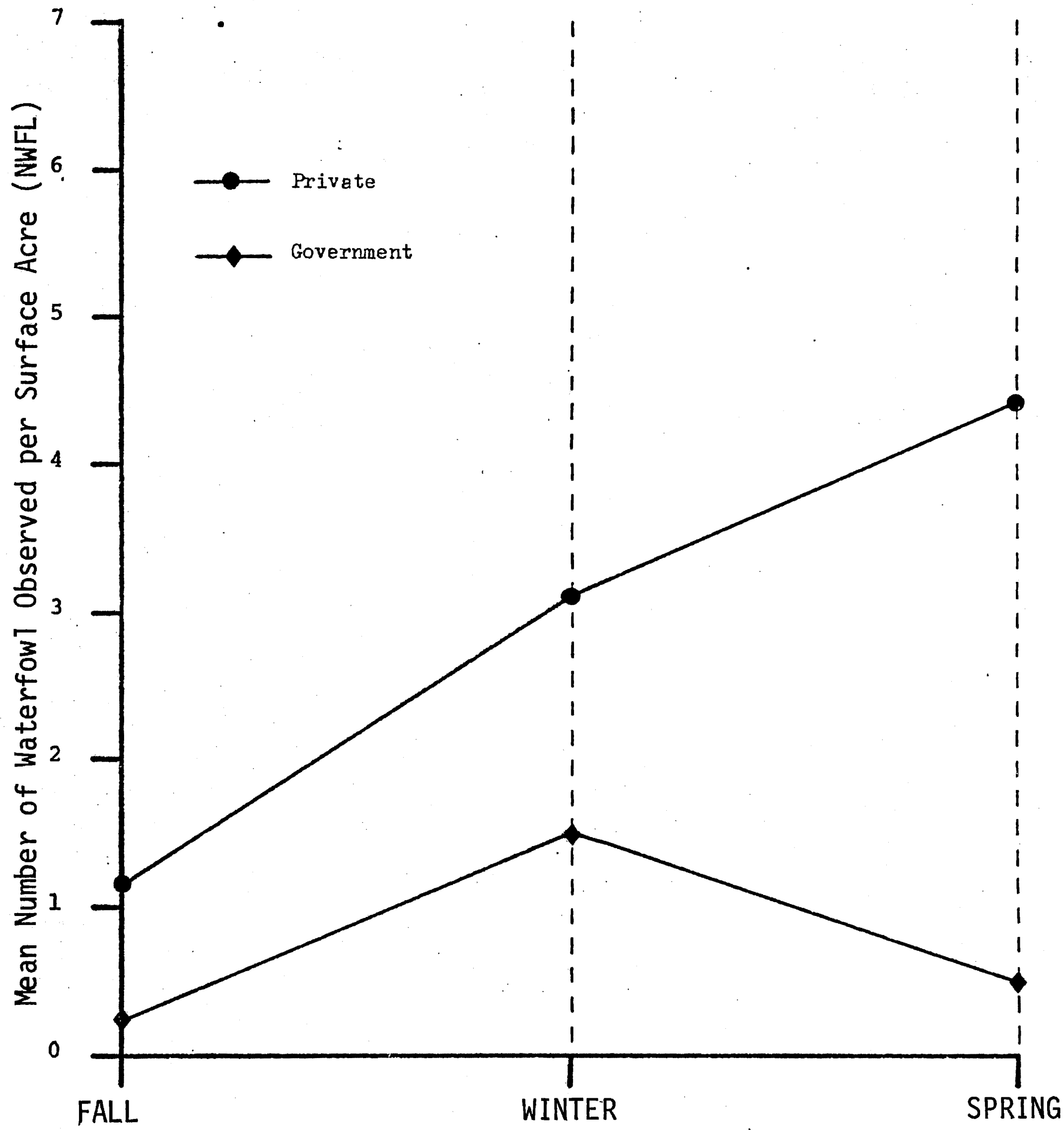


Fig. 22. Comparison of seasonal means for effect due to ownership

factors influencing habitat selection by waterfowl were recognized by those hunters who leased the habitat. It was hypothesized that habitat managed for waterfowl would show a significantly greater use. The lack of significance can be explained by the nature of the fall and spring migration. Fall migrants were not significantly "lured" into managed and/or leased habitat due to their brief occurrence in the watershed. Spring migrants, however, were in the watershed long enough to utilize the leased habitat to a greater degree than the other categories.

No interaction ($p < .25$) was observed between the seasonal effect and effect due to the degree of habitat management.

Extent of Human Disturbance. AOV shows no significant ($p < .25$) difference in NWFL due to the extent of human disturbance (Appendix D, p. 161). Comparison of seasonal means shows that all categories received approximately that same amount of use during the fall and winter seasons. An increase in the "Slight" category was noticed during the spring migration along with a decrease in those impoundments not affected by human disturbance. The original hypothesis was based on an assumed greater use pattern for those impoundments least affected by human disturbance. Non-conformance with this hypothesis was not expected. A possible explanation relates to the nature of migration in the watershed. During the fall, waterfowl were passing through in rapid succession without seeking out potentially preferred habitat. Spring migrants moving through with leisure apparently do not consider human disturbance a significant factor in spring habitat selection.

No significant ($p < .25$) interaction between seasonal effects and effect due to human disturbance was observed.

Degree of Land Posting. AOV shows no significant ($p < .25$)

difference in NWFL due to the degree of land posting (Appendix D, p. 162). Comparison of seasonal means for each category indicates little difference in preference patterns between "Posted" and "Non-posted" land. The insignificant greater use of the "Posted" impoundments during the spring may indicate a slight preference for the more protected impoundments. During the spring, the "Non-posted" impoundments received slightly higher use. It was believed that "Posted" impoundments would be preferred to "Not posted" habitat because of the disturbance factor associated with non-posted land. Non-conformance with expected use patterns may be due to the small sample size for non-posted habitat or as discussed in previous sections, waterfowl selection of habitat may not be strongly influenced by degree of disturbance, especially during the spring.

Presence of Exposed Margins. AOV shows no significant ($p < .25$) difference in NWFL due to the presence of exposed margins (Appendix D, p. 163). Comparison of seasonal means for each category indicates little difference in waterfowl use patterns, except during the winter season. Wintering waterfowl used impoundments with exposed margins to a greater extent than habitat without exposed margins. This pattern does not comply with the original hypothesis that waterfowl would prefer habitat without exposed margins. Non-conformance may be due to the feeding activity of wintering waterfowl. Mallards did not use the small impoundments which usually had exposed margins for feeding; most feeding was done on dry land. Winter use of the smaller impoundments appeared to be more for resting and isolation.

No significant ($p < .25$) interaction between seasonal effects and effect due to the presence of exposed margins was observed.

Dynamic Characteristics

Statistical results and discussion of five Dynamic habitat characteristics are as follows:

Turbidity. Analysis of variance shows no significant ($p < .25$) difference in NWFL for fall, winter, and spring due to the degree of turbidity (Appendix D, p. 164). Fall means for each turbidity category show very little difference in preference patterns (Fig. 23). The use of the clearer impoundments actually decreased during the winter. All categories were equally utilized during the spring migration. A previous study by Barstow (1957) conducted in the watershed indicates that waterfowl may prefer the less turbid impoundments. His study provided the basis for the hypothesis that waterfowl would prefer clear impoundments to turbid ones, and that clearer impoundments are more productive. Data analyses show, however, that turbidity is not a significant factor in habitat preference. A limnological study (Epperson 1972) on turbidity and pond productivity in north-central Oklahoma indicates that productivity is only slightly affected by turbid conditions. Actually, the incoming sediment load causing the turbid conditions hastens ecological succession in an impoundment. As the impoundment proceeds to a more xerophytic stage, the modifications become attractive to migratory waterfowl.

Tests for interaction between seasonal effect and effect due to turbidity shows no significance ($p < .25$). Tests for interaction shows no significant ($p < .25$) influencing effect between turbidity means and seasonal means for aquatic vegetation and water levels. Interaction ($p < .25$) was noted between turbidity and alkalinity and turbidity and

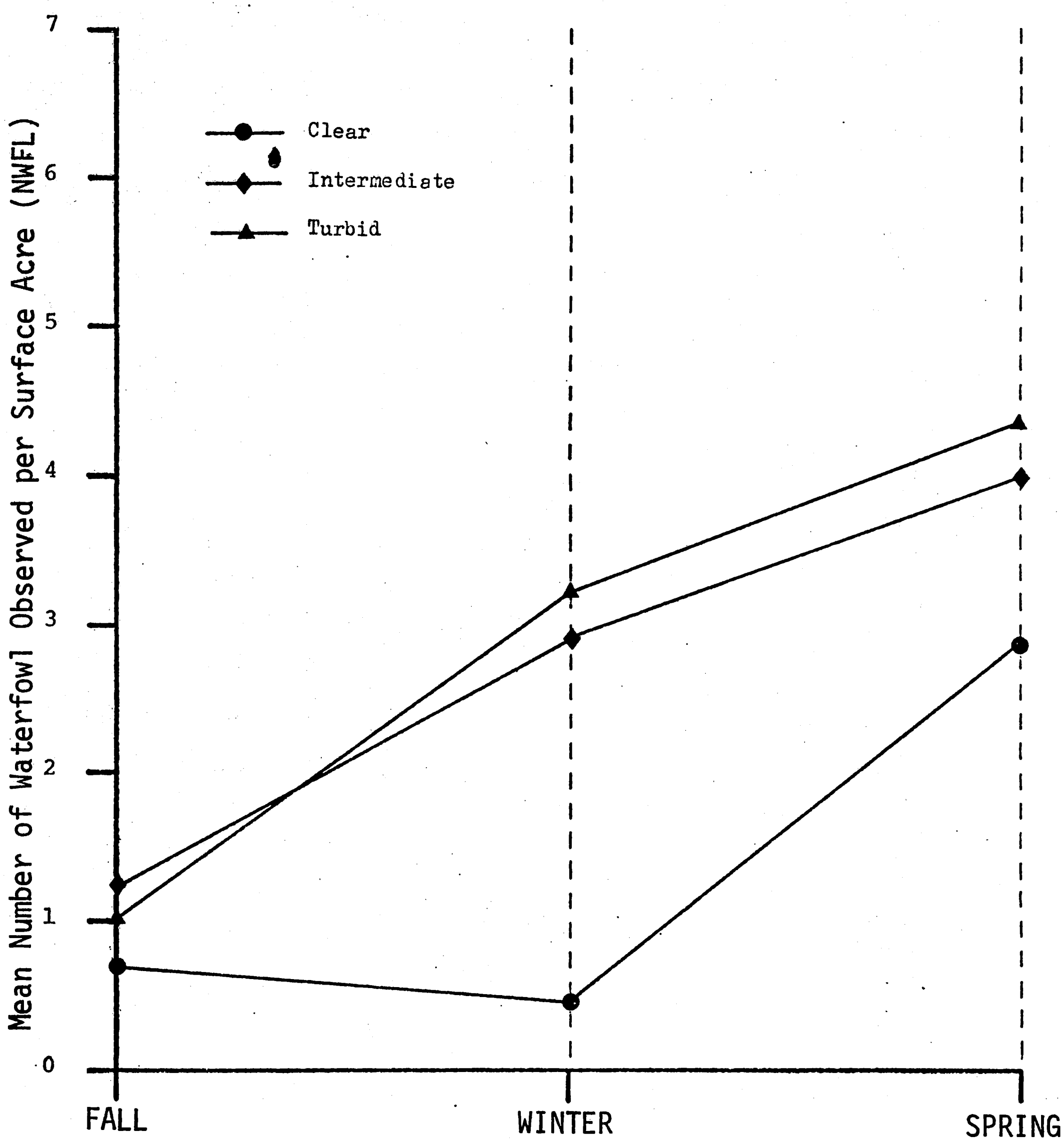


Fig. 23. Comparison of seasonal means for effect due to turbidity

macroinvertebrate abundance. Intrepretation of interaction is discussed below.

Total Alkalinity. Analysis of variance shows a significant ($p < .10$) difference in NWFL during the fall, winter, and spring due to the concentration of $CaCO_3$ alkalinity in an impoundment (Appendix D, p. 164). Comparison of seasonal means for the three alkalinity categories (Fig. 24) supports the hypothesis that waterfowl select the more productive impoundments. Total alkalinity expresses the concentration of two substances necessary to plant life, calcium and carbon dioxide, and also is a result of the entire biological and chemical system of waters (Moyle 1956). This has led to the use of total alkalinity as a rough index of the productivity of waters. Figure 24 shows that the mean NWFL value was the highest for those impoundments with high (> 150 ppm) total alkalinity. Waterfowl utilized the more productive impoundments to an exceptionally high degree during the spring. These data indicate that habitat productivity is an important factor in habitat selection. Since total alkalinity is a measure of biological productivity, waterfowl are actually selecting productive habitat (i.e., abundant aquatic vegetation) rather than high levels of total alkalinity.

A test for interaction between the seasonal effect and effect due to alkalinity was significant ($p < .25$). This was expected since the winter season (cooler temperatures reduces productivity) causes a reduction in habitat productivity reflected by the lower mean NWFL value for the higher alkalinity category. Tests for interaction ($p < .25$) between alkalinity and the other Dynamic habitat characteristics indicate that alkalinity is affected by or affects fall

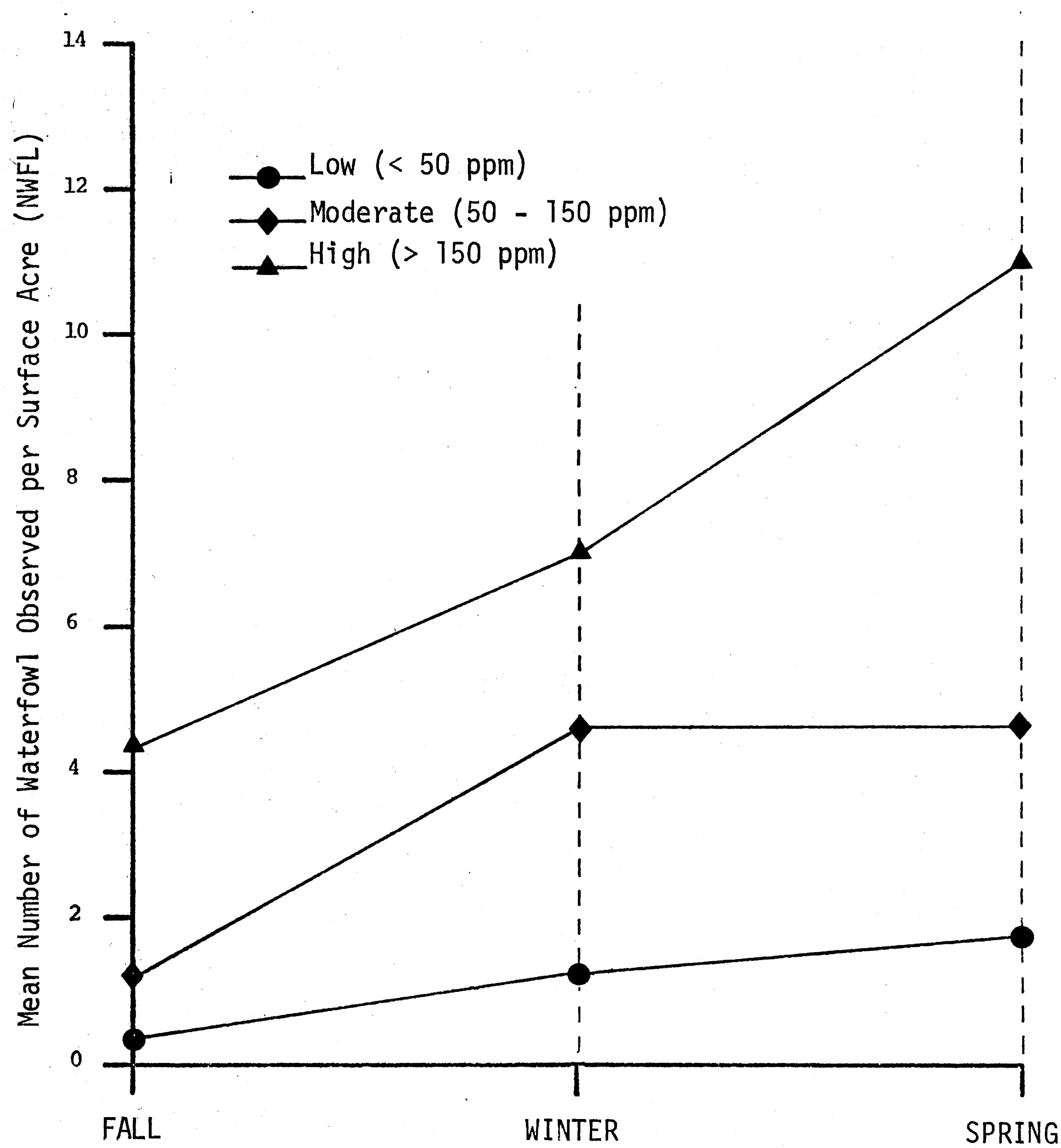


Fig. 24. Comparison of seasonal means for effect due to alkalinity

turbidity levels and winter water levels. During the winter, impoundments with lowered water levels showed an increase in waterfowl use which interacted with impoundment productivity. This may be due to the increased ionic concentration that results from evaporation and water loss. During the fall an increase in alkalinity influenced the use of clear impoundments since the higher ionic concentration due to a high level of productivity reduced turbidity by precipitation of suspended clays.

Aquatic Vegetation Index. AOV indicates a significant ($p < .25$) difference in NWFL during fall and spring due to the amount of aquatic vegetation in an impoundment (Appendix D, p. 164). Comparison of seasonal means (Fig. 25) shows that during the spring, when migration was at a leisure pace, waterfowl preferred impoundments with a high index. This substantiates the hypothesis that impoundments with a greater amount of aquatic vegetation would be preferred to those with a lesser amount. The dominance of impoundments with a low index during the fall can be explained by the nature of the fall migration. Most of the larger impoundments (e.g., Lake Carl Blackwell, Ham's Lake), which were preferred during the fall, have a low aquatic vegetation index. This would indicate that during the fall, habitat selection was based more on protection and safety rather than food availability. Although not significant, the use of impoundments with a high index during the winter was greater than those with a lower index.

Test for interaction between seasonal effect and effect due to aquatic vegetation index is not significant ($p < .25$). No interaction ($p < .25$) was noticed between aquatic vegetation effects and effects from the other Dynamic habitat characteristics. Effects due to aquatic

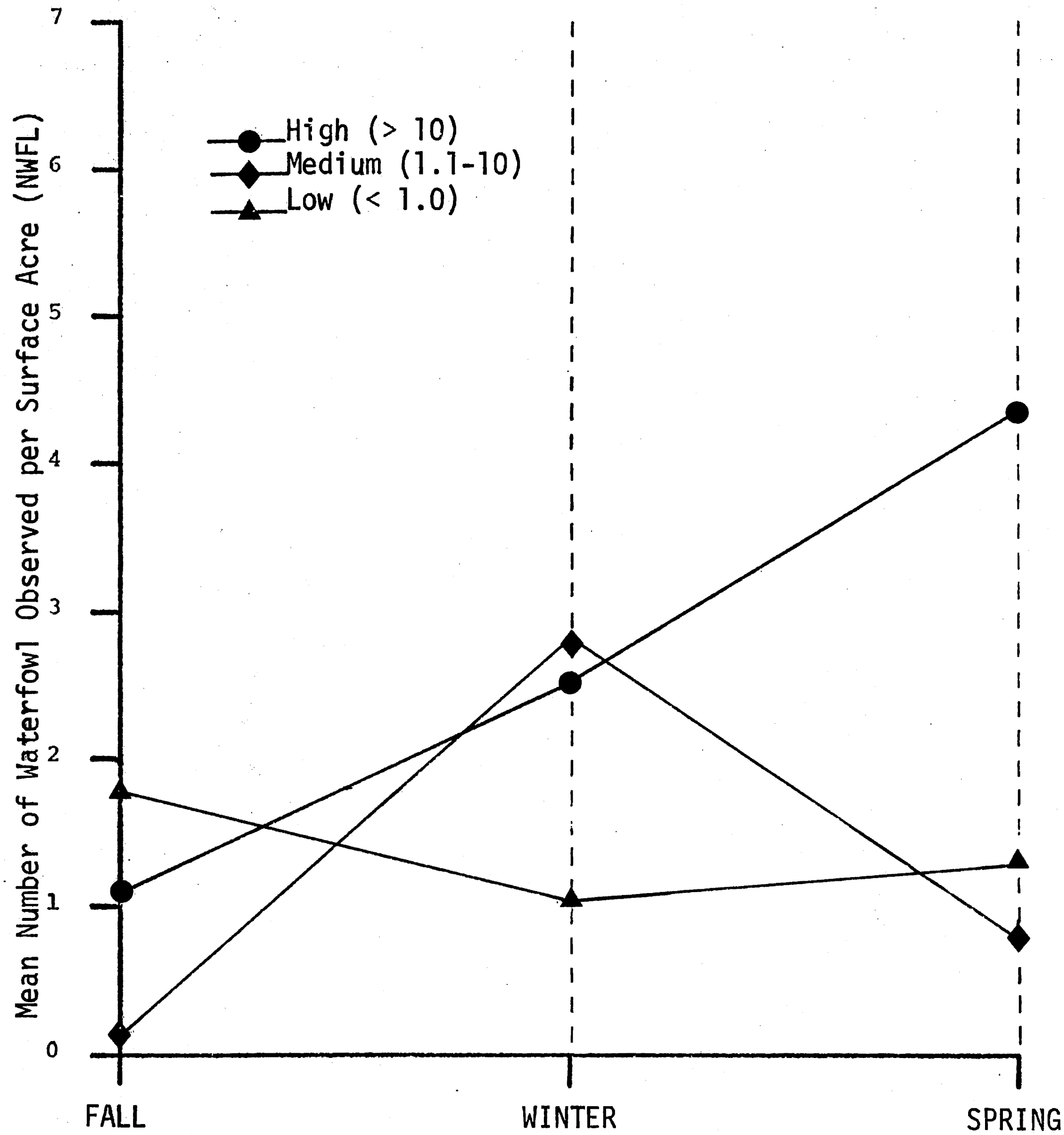


Fig. 25. Comparison of seasonal means for effect due to aquatic vegetation index

vegetation parallel those for alkalinity, since alkalinity is affected by primary productivity of aquatic vegetation.

Macroinvertebrate Abundance. Analysis of variance shows significant ($p < .25$) difference in NWFL during fall and spring due to the abundance of macroinvertebrates in an impoundment (Appendix D). Comparison of seasonal means (Fig. 26) supports the hypothesis that waterfowl prefer impoundments with an abundant amount of macroinvertebrates. Macroinvertebrates are important food items (Martin and Uhler 1951 and Hancock 1956) for migratory waterfowl, especially during the spring. The lack of difference between the two categories during the winter is explained by the reduction in macroinvertebrates due to the colder water temperatures in the winter. Since macroinvertebrate abundance is related to the amount of aquatic vegetation, impoundments with a low aquatic vegetation index contain few macroinvertebrates.

Test for interaction between seasonal effect and effect due to macroinvertebrate abundance shows no significance ($p < .25$). No interaction ($p < .25$) was detected between effects due to macroinvertebrate abundance and effects due to alkalinity, aquatic vegetation, and water levels. This conforms to the parallel effects of alkalinity, aquatic vegetation, and macroinvertebrate abundance, all an expression of impoundment productivity. Fall interaction ($p < .25$) between macroinvertebrate abundance and turbidity was significant. Comparison of fall means for both effects (Appendix D) show that turbid impoundments interact with macroinvertebrate abundance, reflecting increased waterfowl use for turbid impoundments with high levels of macroinvertebrates.

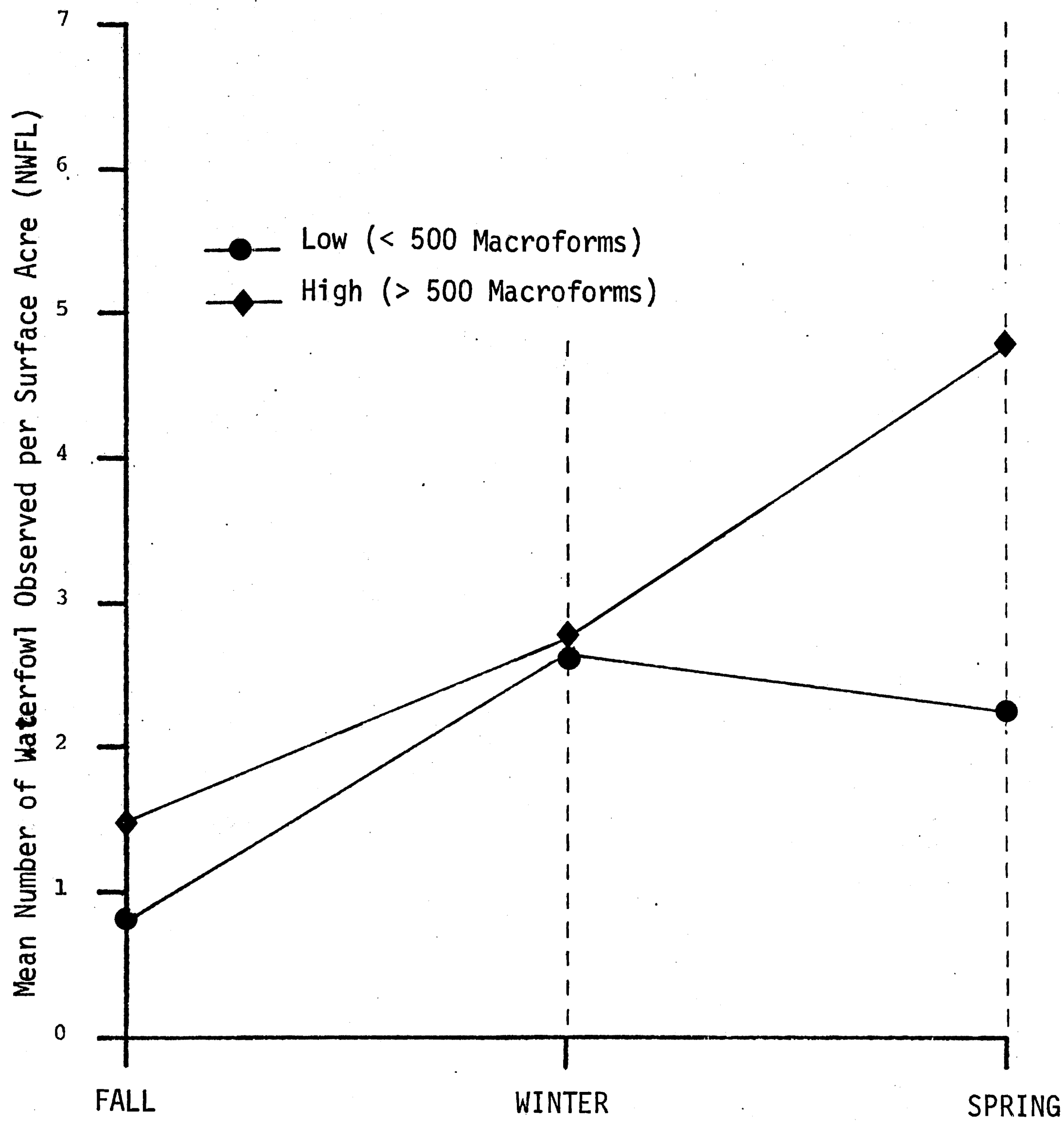


Fig. 26. Comparison of seasonal means for effect due to macro-invertebrate abundance

Water Level. AOV shows a significant ($p < .25$) difference in NWFL during the spring due to the water level of an impoundment (Appendix D). Comparison of seasonal means (Fig. 27) indicates that impoundments with a "Below Normal" water level were preferred during the spring migration. The spring of 1972 was unusually dry for the watershed; no impoundments surveyed were placed in the "Above Normal" category. It was hypothesized that impoundments with an "Above Normal" or "Normal" water level would be preferred to the "Below Normal" impoundments. In the pothole production areas water level is a significant factor affecting habitat use. However, in the Stillwater Creek Watershed, selection of habitat is apparently not based on water levels. Since the watershed is dominated by Type 5 Permanent Wetlands (Shaw and Fredine 1956) lowered water levels did not significantly reduce the number of available impoundments, nor did it affect the use of these impoundments.

Test for interaction between seasonal means and effect due to water levels shows no significance ($p < .25$). No interaction was detected between water level effect and effects due to other Dynamic habitat characteristics except for winter levels of alkalinity, as previously discussed.

## Weather Influences

A statistically significant (distribution of "F" at 10 percent and 25 percent) difference in the mean number of waterfowl counted per observation was noted for 6 of the 13 computed AOV tables and the 6 are discussed below. The remaining 7 weather parameters did not significantly affect the number of waterfowl observed (Table XIV).

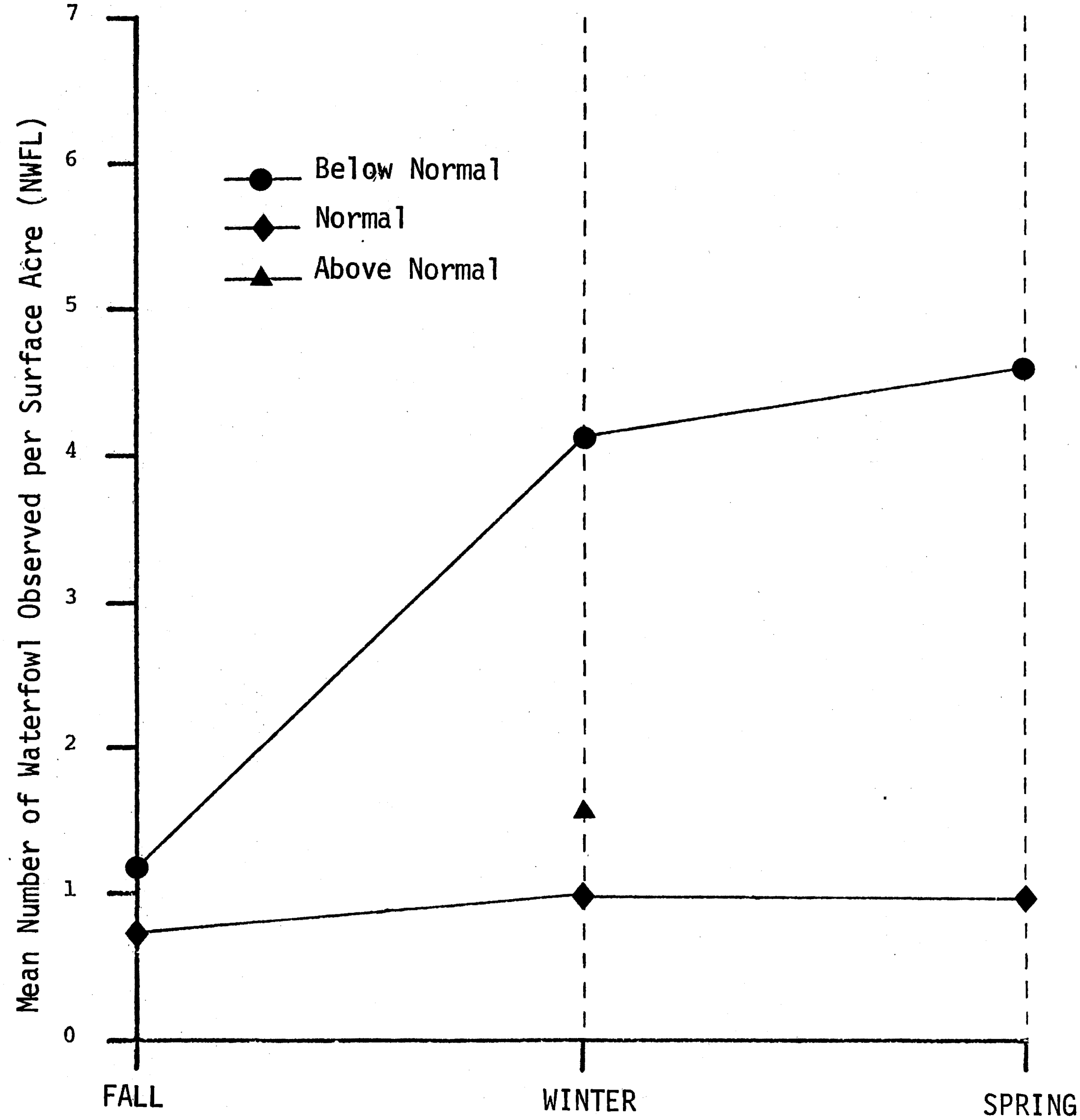


Fig. 27. Comparison of seasonal means for effect due to water levels

## Seasonal Effect

Statistical analyses show a significant difference ($p < .10$ in the mean number of waterfowl observed per observation due to the season of migration. Newman-Keuls ranking of seasonal means (winter > fall > spring) indicates that the sinter mean is significantly ($p < 0.05$) higher. The winter increase in waterfowl per observation is due to the nature of the migration, as previously discussed. Large concentrations of mallards and common mergansers on a few impoundments results in a high mean number of waterfowl per observation.

## Air Temperature

Analysis of variance shows a significant ($p < .25$) difference in the mean number of waterfowl counted per observation due to wind direction. Newman-Keuls ranking of means (West > South, North, or East) indicates that a significantly ($p < 0.05$) greater number of waterfowl were counted per observation when the wind was out of the "West". Dominant wind direction during the winter and early spring is from the west-southwest which usually brings warm temperatures and clear days. Since westerly winds are associated with the passing of a strong high pressure system, the increase in waterfowl may be due to an influx of birds moving northward, perhaps beginning their spring migration. Strong northerly and easterly winds tend to move birds out during the fall and winter periods.

TABLE XIV

SUMMARY OF STATISTICAL DIFFERENCES IN THE MEAN NUMBER OF WATERFOWL OBSERVED DUE TO 13 WEATHER PARAMETERS

Significant ($p < .10$) Difference in the Mean Number of Waterfowl Observed Due To:

Current Precipitation
Distance Watershed is Behind a Major Front

Significant ($p < .25$) Difference in the Mean Number of Waterfowl Observed Due To:

Air Temperature
Wind Direction
Wind Speed
Wind Chill Index

No Significant Difference in the Mean Number of Waterfowl Observed Due To:

General Weather Situation
Visibility
Cloud Cover
Past Precipitation
Barometric Pressure
Distance Watershed is Ahead of a Major Front
Amount of Ice Cover

Wind Speed

Analysis of variance shows a significant ($p < .25$) difference in the mean number of waterfowl counted per observation due to wind speed. Newman-Keuls ranking of means (16-32 kph > 0-16 kph, 32-48 kph and over 48 kph) indicates that the mean number of waterfowl observed was significantly ($p < 0.05$) higher during wind speeds of 16-32 kph. This indicates that strong winds (usually northerly in fall and southerly in spring) are taken advantage of by migrating waterfowl. Major movements were noticed during periods of strong wind when the direction was compatible with the migration direction. Winter wind speed in the watershed averages over 16 kph, perhaps accounting for its significance.

Wind Chill Index

Analysis of variance shows a significant ($p < .25$) difference in the mean number of waterfowl counted per observation due to the wind chill index. Newman-Keuls ranking of means (over 0° C > 0° to -12° C and -12 to 23° C and less than -23° C) shows that a significantly ($p < 0.05$) greater number of waterfowl were counted per observation when the wind chill index was low (i.e., low wind velocity with moderate temperatures). The wind chill index brought about the most predictable effects in the watershed. Cold temperatures accompanied by strong winds (high wind chill index) consistently moved waterfowl out of the watershed.

## Current Precipitation

Analysis of variance shows a significant ($p < .25$) difference in the mean number of waterfowl counted per observation due to the current precipitation. Newman-Keuls ranking of means (No precipitation$>$ Light Rain, Snow/Sleet and Heavy Rain) indicates that the mean number of waterfowl counted per observation was significantly ($p < .05$) higher during periods of "No Precipitation" or "Light Rain". "Light Rain" did not appear to influence waterfowl numbers to the extent that "Heavy Rain" did. Most periods of heavy rain were preceeded by strong winds associated with a strong front which moved out waterfowl. Temperatures cold enough to produce snow also forced most waterfowl out of the watershed. The time honored hunter's forcast of "duck weather" (i.e., cold and wet) actually brought about a reduction in waterfowl numbers in the watershed.

## Distance Watershed is Behind a Major Front

Analysis of variance indicates a significant ($p < .10$) difference in the mean number of waterfowl counted per observation due to the distance the watershed is behind a major front. Newman-Keuls ranking of means (1600 to 800 km $>$ 800 to 400 km $>$ 400 to 100 km, no front, less than 160 km, and over 1600 km) shows that a significantly ($p < .05$) greater number of waterfowl were counted per observation when a major front was from 400 to 1600 km south - southeast of (behind) the watershed. This data supports the hypothesis that a strong front moves out waterfowl. The nearer the front was to the watershed, the fewer number of waterfowl observed. Under normal patterns, the weather is clear and calm in the watershed after a major front has moved south (400 to 1600 km). An increase in waterfowl numbers follows the passage of the front, in between the front just moving out and ahead of the next one moving in.

# CHAPTER V

# SUMMARY AND CONCLUSIONS

Selection of impoundments by waterfowl in the Stillwater Creek Watershed during 1971-1972 was apparently influenced by the nature of migration, disturbance (i.e., hunting) factors, weather influences, and habitat characteristics. All factors interacted, to some degree, which tends to mask the overall effect of specific Static and Dynamic habitat characteristics. However, eight Static and four Dynamic habitat characteristics were shown to significantly affect impoundment selection. These same habitat characteristics, important components of waterfowl habitat, are known to function on the breeding grounds (Trauger 1967; Bennett 1938; Evans et al. 1952; Smith 1953; Stewart and Kantrud 1971; and others).

Weather conditions were shown to exert a strong and varied influence on waterfowl movements and impoundment selection in the watershed. The number of waterfowl counted per observation was significantly affected by six of the thirteen weather parameters studied. These same weather influences have been shown to influence waterfowl migration and habitat selection in other parts of the United States (Barclay 1970; Welty 1962; Miskimmen 1955; Lawrence 1964; and others).

## Migration Chronology

Census data from over 1800 observations on 23 species of waterfowl revealed that dabblers accounted for 62 percent, divers 20 percent, mergansers 17 percent, and geese and swans 1 percent of the 118,120 waterfowl observed. The mallard was the most common waterfowl species observed in the watershed contributing over 22 percent to the total. In general, weekly numerical fluctuations of individual waterfowl species observed in the watershed were similar to that reported by Buller (1964), Metzen (1966), Barstow (1957), Lawrence (1964), and others. These data would indicate that the Stillwater Creek Watershed is capable of supporting a suprisingly large number of waterfowl, especially for an area considered marginal in waterfowl habitat.

An average of 52 waterfowl per observation, representing over 16 species, were counted during the fall migration. The fall build-up, occurring the week preceeding the opening of the fall waterfowl hunting season (October 10-16, 1971) was dominated by early migrants such as wigeon, gadwall, blue- and green-winged teal. A rapid population decline was noted after the opening of the hunting season (October 16, 1971). Migration chronology through the watershed during the fall can be described as rapid. Flights were massed, quickly reaching peak numbers, with a rapid decline as the season progressed. The early migrants, teal, gadwall, and wigeon, appeared in the watershed by mid-September, and were gone by late October. Mallards became more numerous as the season progressed, reaching a seasonal high of 32 percent at the end of the fall migration. From these data it may be concluded that the Stillwater Creek Watershed provides primarily migrational habitat for teal, gadwall, and wigeon, whose weekly fluctuations are similar to that reported by other investigators and are influenced by hunting pressure.

During the winter, an average of 96 waterfowl per observation, representing over 21 species, was counted. The dominant species observed were mallard and common merganser, accounting for over 65 percent of the total number of waterfowl observed. Both the mallard and the common merganser were not characteristic of migrants. Instead of a massed flight, their numbers began to increase with the winter, reaching a sustained level from December 20, 1971 to February 12, 1972. This is typical of wintering species. The unusual dominance of common mergansers in the watershed can be attributed to Lake Blackwell, a warm-water reservoir which provided an abundance of forage fish for the common merganser (Miller 1973). Less dominant winter waterfowl included pintail, lesser scaup, and ring-necked duck. Wintering chronology for individual species observed in the watershed was similar to that reported by Kortright (1953), Rue (1973), Robbins et al. (1966), Buller (1964), and others. The mallard and common merganser are late southward migrants, wintering as far north as weather conditions permit. Lesser scaup and ring-necked ducks are late fall - early winter migrants. From these data it is concluded that the Stillwater Creek Watershed provides winter habitat requirements for mallards and common mergansers and migrational habitat for lesser scaup and ring-necked ducks. The largest concentration of waterfowl occurred during January 30 to February 5, 1972, when an average of 500 waterfowl were counted per observation.

During the spring, an average of 46 waterfowl, representing over 18 species, were counted per observation. The most frequently observed waterfowl was the ring-necked duck, contributing 23 percent to the seasonal total, followed by the pintail, green-winged teal, blue-winged teal, and wigeon. In contrast to the fall, when most waterfowl observed were of four species, the spring was characterized by a greater diversity of waterfowl. Spring waterfowl movements were at a leisurely pace in contrast to the massed flights of the fall. These changes in chronology have been reported by Buller (1964), Metzen (1966), and Kortright (1953) and appear to be influenced by weather conditions and hunting pressure. During the fall, hunting pressure is believed to force birds to use the large impoundments which provide some degree of protection. The absence of hunting pressure in the spring allows for leisurely movements and a wider dispersion of waterfowl. Weather conditions also may perpetuate the difference between the fall and spring migration chronology. During the fall, waterfowl moved out of the watershed ahead of strong cold fronts with their accompanying northerly winds. The intensity of these cold, northerly winds produced a rapid movement of waterfowl. In the spring, however, the prevailing warm southwesterly winds were of low enough velocities that rapid waterfowl movements were not observed. From these data, it is concluded that the Stillwater Creek Watershed provides primarily spring migrational habitat for ring-necked duck, pintail, green-winged teal, and blue-winged teal, whose numbers are widely dispersed throughout the watershed. Species diversity is highest during the spring due to the un-hurried nature of the waterfowl movements.

Nesting waterfowl in the Stillwater Creek Watershed were limited to a brood of released McGraw mallards and seven wood duck ducklings located on Hams' Lake. The general lack of nesting waterfowl may be due to a combination of factors, including high ground temperatures, disturbance, and poor habitat conditions. The general overgrazed condition of most watersheds, especially near an impoundment, reduces the necessary nesting cover for waterfowl. This lack of nesting cover also contributes to an elevated ground temperature which may affect the development of the duck embryo. Disturbance by cattle probably reduces the attractiveness of an impoundment to nesting waterfowl. From these data it is concluded that the Stillwater Creek Watershed does not provide the necessary habitat for nesting waterfowl.

## Utilization of Impoundments

Each intensively surveyed impoundment (100) was ranked according to 19 Static and 5 Dynamic habitat characteristics. This resulted in a wide variability of habitat types in the watershed which were available to waterfowl throughout the migration and wintering periods. An intensive impoundment survey, in combination with a waterfowl census, provided data on the seasonal preference (in NWFL) of each Static and Dynamic habitat characteristic. From statistical analyses (AOV) it was concluded that 8 Static and 4 Dynamic habitat characteristics were significantly selected for by migratory waterfowl in the Stillwater Creek Watershed from August 29, 1971 to April 22. 1972. These selection or preference patterns were influenced by the season of the year and, to some degree, by the weather.

Analysis of seasonal effects shows that the mean NWFL increased from fall (NWFL = 1) to spring (NWFL = 4) which was reflected in the type of habitat utilized throughout the watershed. The most significant difference in preference patterns from fall to spring was the size of the preferred impoundment. During the fall, waterfowl selected the larger, more isolated impoundments; in the spring, however, the smaller, typical farm ponds were preferred. The basis for the difference was due to migration chronology and hunting pressure. Fall flights were massed and quick, occurring during Oklahoma's waterfowl hunting season. The rapid build-up and move-out of each waterfowl species and the selection of the more protected habitat offered by a larger impoundment, reduced the fall NWFL value. During the spring, however, waterfowl movements were at a more leisurely pace, allowing the birds to select the smaller, less isolated farm ponds, as was reflected by an increased spring NWFL value. The seasonal effect (i. e., the difference in NWFL throughout the year) was the most readily identifiable outcome of the different habitat preference patterns.

One of the eight Static characteristics which illustrates the seasonal and weather influence is dam orientation. During the fall, all orientations were equally utilized. Weather fronts in the fall typically moved-out migratory waterfowl; their selection of impoundments with north facing dams was not significant. During the winter, however, when mallards were the dominant wintering waterfowl, cool, southerly winds were a factor in the increased use of south facing dams. In the spring, when cool, westerly winds were dominant, waterfowl preferred the western facing dams. It is concluded from these data that dam orientation was an important habitat component in the Stillwater Creek Watershed during the study period.

The topography surrounding an impoundment's watershed was a functioning habitat component during the study. The fall preference of the "Closed" impoundments (i.e., ponds not easily seen) correlates with the protection required by fall migrants, especially during the hunting season. Mallards, however, utilized the "Semi-closed" impoundments during the winter, apparently for protection from hunting pressure and cold winds. The "Open" impoundments showed a significant increase in use during the spring, when isolation was not critical. This same preference pattern was observed for the shoreline development index. Fall migrants did not select impoundments for their degree of shoreline configuration. Instead, preferred habitat in the fall were the large impoundments with moderately developed shorelines. During the winter and spring, however, the use of the "Round" impoundments was significant. Impoundments with a "Round" shoreline are the farm ponds which were preferred by the spring migrants.

Because "Round" impoundments tend to have a "low" maximum depth-surface relation, the seasonal selection of impoundments with shallow edges parallels the selection of "Open", or less configured impoundments. The springtime preference of "Round" and shallow impoundments may be due to their early aquatic vegetation and macroinvertebrate abundance due to the increase in the euphotic zone in these type of impoundments. From these data it is concluded that the surrounding topography and the maximum depth-surface relation of an impoundment are related, and together they function as important components of waterfowl habitat in the Stillwater Creek Watershed. The springtime selection of round and shallow impoundments, however, is probably due to the early abundance of vegetation and macroinvertebrates, not the configuration and degree of slope itself.

Statistical analysis shows a winter and spring preference for impoundments located closer than 0.4 km to a section road. The springtime preference for the small, farm ponds and the absence of hunting pressure allows for a wider dispersion of waterfowl throughout the watershed and an increase in the use of impoundments located near a section road. It is concluded that the location of the section road itself does not influence habitat selection.

Data on the influence of a major impoundment reveals that Lakes Carl Blackwell, McMurtry, Hams, and Boomer exert a "satellite" effect on surrounding impoundments. During all seasons, impoundments located within 0.4 km of a major impoundment were preferred over impoundments located at greater distances. From these data it is concluded that the large impoundments are the main attractive force in the watershed, as they are the most easily seen habitat from the air. Once the birds are attracted to and settle on these large impoundments, however, they tend to disperse to the smaller ponds, especially during the winter and spring.

Analysis of ownership data shows a lack of preference for government owned impoundments. Most of these were SCS structures which lack the preferred habitat characteristics shown to be significantly selected. During the spring, the increase in use of the small farm ponds reflects the preference for private impoundments. From these data it is concluded that the SCS structures built in the Stillwater Creek Watershed as of April 1972, do not provide the preferred habitat characteristics selected for by migrating waterfowl.

Four Dynamic characteristics were shown to be important habitat components for migratory waterfowl in the watershed. Total alkalinity, a measure of production, was shown to be a significant factor in habitat selection. Impoundments with total alkalinity > 150 ppm were preferred over the less productive (< 50 ppm) impoundments during all seasons of the study. Since total alkalinity is the result of the entire biological and chemical system of the water, it is concluded that total alkalinity is a good measure of impoundment production. The more productive the impoundment (usually reflected by high values of total alkalinity), the more likely it will be utilized by waterfowl.

Data on aquatic vegetation and macroinvertebrates show that the availability of food in an impoundment was an important waterfowl selection criteria during winter and spring of the study period. During the fall, however, the quick build-up and movement of waterfowl numbers, in combination with hunting pressure, did not allow waterfowl the opportunity to select impoundments with high levels of aquatic vegetation and macroinvertebrates. From these data it is concluded that impoundments with high levels of aquatic vegetation and macroinvertebrates are preferred by waterfowl during the winter and spring when migration chronology and lack of disturbance permits their preference.

Selection of impoundments with lower than normal water levels were significant during the winter and spring. Due to the below-normal annual rainfall received in the watershed during the study period, it was concluded that the complete dominance of impoundments with low water levels masked the expected preference of impoundments with above-normal water levels. Even under low rainfall conditions, however, the watershed provided valuable waterfowl habitat.

Turbidity was shown not to affect impoundment selection by waterfowl. It is concluded that due to the generally turbid conditions in north-central Oklahoma impoundments (Epperson 1972), their expected differential preference by waterfowl was not observed and was therefore not a functioning habitat characteristic in the watershed during the study period.

## Weather Influences

Statistical analyses of weather influences on biological populations is difficult, often yielding unexplained results not correlating with observed trends. A controlled study of habitat preference without the modifying effects of weather would be ideal, but impossible. Interpretation of weather influences should be considered somewhat separate from habitat preferences. Only in a few cases, described below, did weather conditions force a noticeable difference in habitat use patterns. It is probable that weather has an even greater effect on habitat choice than shown in this study, albeit difficult to measure and define.

Weather influences migration in at least three different ways (Welty 1962). It controls the advance of the seasons, or the phenology of natural events. It effects the migrating species in flight - helping or hindering - and weather may be the stimulus that initiates the migration journey in a bird physiologically prepared for it. All categories of influences appear to function in the Stillwater Creek Watershed. Many studies have been made of the more direct influences of weather of birds while they are migrating. Attempts to correlate migration movements with barometric pressure, wind direction, precipitation, and temperature have resulted in conflicting conclusions. However one consistency did appear; the spring movements of migrating birds usually coincided with the flow of warm, moist, south winds from the Gulf of Mexico. Adverse weather may impede migration and cause concentrations of birds, which again move with the return of favorable weather.

Comparison of weather influences affecting habitat selection and migration chronology in the Stillwater Creek Watershed with other studies shows some similarities. Lacks extensive review (1960) of the influence of weather on migration concludes that migration is relatively unaffected by the general weather situation as such, or by barometric pressure or wind direction. However, his review shows that more migration occurs in fair weather with clear skies and light winds than in rain, cloudy weather, or strong winds. Further, migration generally occurs in spring with warm weather and in the fall with cold. These same factors appear to function in the Stillwater Creek Watershed.

The number of waterfowl counted per observation was significantly affected by six weather conditions - air temperature, wind direction, wind speed, wind chill index, current precipitation, and distance that the watershed is behind a major front.

Air temperature is a result of the season of the year. The increase in waterfowl numbers during cool (0-10° C) temperatures is due to the onset of the fall migratory season. Cold temperatures (<0° C) which occurred during the wintering period, were apparently enough of a deterent to wintering mallards that the ability to observe them was significantly less. It is concluded that the preference for cool air temperatures coincides with the fall and spring migration and is in itself not a reason for observing more waterfowl. Cold temperatures, however, were a factor in reducing the population of wintering mallards.

More waterfowl were observed in the watershed when the wind was out of the west, the dominant direction during the early spring. The west-southwest wind in the spring typically brought clear, warm days, associated with a strong high pressure system, factors which favor northward migration. Strong northerly winds in the fall and winter, however, were successful in moving waterfowl southward. It appears that light, westerly winds in the spring were a stimulus to migrating waterfowl, and increased their numbers in the watershed.

A wind speed of 16 to 32 kph was a factor in waterfowl movements in the watershed during the study period. Since the lack of wind tends to reduce daily movements, a lower number of waterfowl were observed under a windless condition. The light wind speed seemed to favor waterfowl movements, resulting in an increase in waterfowl populations. Wind speeds over 32 kph did, however, move out migrating waterfowl in the watershed.

The wind-chill index is a measure of the combined effect of temperature and wind speed. The lowest level (< -23° C) had the most predictable effect on waterfowl. The low index, which results from low temperatures and strong winds, consistently moved waterfowl out of the watershed.

Data on precipitation shows that the mean number of waterfowl counted per observation was significantly higher during periods of no precipitation or light rain. Periods of heavy rain, snow and sleet, usually preceeded by a strong cold front, forced most waterfowl out of the watershed. These data would indicate that hunting waterfowl in cold, wet weather ("duck weather") was probably not the best situation for observing waterfowl in the watershed during the study period.

A significant increase in the number of waterfowl counted per observation was shown after a front had passed through and was from 400 km to 1600 km south of the watershed. From these data it is concluded that the closer a front is to the watershed, the fewer waterfowl will be observed. This would indicate that an incoming strong front moves birds out of the watershed, with an increase in waterfowl numbers only after the passage of the front at least 400 km to the south.

## Management Recommendations

A number of management recommendations and concepts emerge from this study, based on habitat characteristics, weather influences, and migration chronology. These recommendations and concepts are enumerated below.

1. Habitat requirements of fall migrants are different from spring migrants.
2. Fall migrants prefer large, isolated impoundments which provide protection from hunting pressure.
3. Fall migration is quick, characterized by a wave-like movement of each important waterfowl species.
4. Since waterfowl prefer the larger impoundments during the fall, management programs should be directed at these structures.
5. Because of the "satellite" effect of large impoundments, management of small impoundments located approximately 0.4 km away would be beneficial.
6. Since the large impoundments lack abundant aquatic vegetation, a recommended management scheme should include wetland vegetation management and food crop (i.e., sorghum) plantings.
7. The larger SCS structures could be more utilized in the fall if, in their construction design, shallow areas were considered and planned for.
8. Wintering mallards utilize large impoundments for resting and

small impoundments for daily feeding.

9. Management of these small impoundments might include the planting of small feed plots with grain.

10. An abundant dry-land food supply (e.g., sorghum) during severe freeze-up conditions would keep more mallards in the watershed.

11. Spring migrants prefer small, isolated impoundments with abundant aquatic vegetation and macroinvertebrates.

12. Since spring migrants prefer the more productive impoundments, management techniques might include winter drawdown of non-productive farm ponds to stimulate aquatic vegetation.

13. Although data analyses did show significant reduction in waterfowl use, a less turbid pond tends to be more productive. Therefore, better management of an impoundments' watershed should make the impoundment more productive.

14. Impoundments with western facing dams are important to spring migrants.

15. Stillwater Creek Watershed does not provide sufficient nesting habitat for migratory waterfowl. Management of Lakes McMurtry, Hams' and Blackwell for wood duck would have potential for increasing this species locally.

16. Better management of an impoundment's watershed might induce blue- and green-winged teal nesting, although probably not in significant numbers.

17. The Stillwater Creek Watershed provides important waterfowl habitat during the fall, winter, and spring due to specific Static and Dynamic habitat characteristics that are present in the watershed. Management for the preferred characteristics should increase waterfowl numbers.

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APPENDIX A

PARTIAL LISTING OF PLANT SPECIES
ENCOUNTERED IN THE STILLWATER
CREEK WATERSHED

| COMMON NAME | SCIENTIFIC NAME |
|---|---|
| Terrestrial Associations | |
| Bermuda grass | Cynodon dactylon |
| Big bluestem | Andropogon gerardi |
| Buffalo grass | Buchloe dactyloides |
| Crab grass | Digitaria sp. |
| Foxtail | Setaria sp. |
| Hairy grama | Bouteloua hirsuta |
| Indian grass | Sorghastrum nutans |
| Johnson grass | Sorghum halepense |
| Little bluestem | Andorpogon scoparius |
| Purple love grass | Eragrostis spectabilis |
| Purple top | Tridens flavus |
| Silver bluestem | Andropogon saccharoides |
| Switch grass | Panicum virgatum |
| Tall dropseed | Sporobolus asper |
| Blue grama | Bouteloua gracilis |
| Wild indigo | Baptisia australis |
| Lousiana sagewort | Artemisia ludoviciana |
| Dotted gayfeather | Liatris punctata |
| Broomweed | Gutierrezia dracunculoides |
| Prairie three-awn | Artistida olignatha |
| Sand drop-seed | Sporobolus cryptandrus |
| Buckbrush | Symphoricarpos orbiculatus |
| Bull thistle | Cirsium vulgare |
| Dandelion | Taraxacum sp. |
| Cocklebur | Xanthium pensylvanicum |

| | |
|---|---|
| Shepherdspurse | Capsella bursa-pastoria |
| Virginia pepperweed | Lepidium virginicum |
| Yellow nutsedge | Cyperus esculentus |
| Virginia copperleaf | Acalypha virginica |
| Carolina geranium | Geranium carolinianum |
| Field sandbur | Panicum pauciflorus |
| Henbit | Lamium amplexicaule |
| Pokeberry | Phytolacca americana |
| Curlydock | Rumex crispus |
| Jimsonweed | Datura stramonium |
| Horsenettle | Solanum carolinense |
| Silverleaf nightshade | Solanum elaeaginifolium |
| Common yellow woodsorrel | Oxalis stricta |
| Groundcel | Senecio sp. |
| Brome | Bromus japonicus |
| Canadian wildrye | Elymus canadensis |
| Post oak | Quercus stellata |
| Blackjack oak | Quercus marilandica |
| Green ash | Fraxinus pennsylvanica |
| Eastern red cedar | Juniperus virginianius |
| Hackberry | Celtis sp. |
| Black locust | Robinia pseudo-acacia |
| American elm | Ulmus americana |
| Red bud | Cercis canadensis |
| Grapevine | Vitis sp. |
| Giant ragweed | Ambrosia trifida |
| Goldenrod | Solidage sp. |

| | |
|---|---|
| Greenbriar | Smilax bona-nox |
| Heath aster | Aster ericoides |
| Ironweed | Vernonia sp. |
| Lead plant | Amorpha canescens |
| Lespedeza | Lespedeza sp. |
| Nightshade | Solanum sp. |
| Pitcher sage | Salvia azurea |
| Prickly pear | Opuntia sp. |
| Showy partridge pea | Cassia fasciculata |
| Sumac | Rhus sp. |
| Sunflower | Helianthus annuus |
| Tick clover | Desmodium sessilifolium |
| Western ragweed | Ambrosia psilostachya |
| Yarrow | Achillea sp. |
| Yucca | Yucca sp. |
| Poison ivy | Toxicodendrom radicans |
| Red root pigweed | Amaranthus retroflexus |
| Spiny amarantha | Amaranthus spinosus |
| Common lambsquarter | Chenopodium album |
| Chickweed | Stellaria media |
| Western yarrow | Ambrosia artenisia |
| Horseweed | Erigepon canadensis |
| Dogfennel | Eupatorium capillifolium |
| Bitter sneezeweed | Helenium amarum |
| Blackberry | Rubus sp. |
| Rough leaf dogwood | Cornus drummondii |
| Sand plum | Prunus angustifolia |

| | |
|---|---|
| Pecan | *Carya illinoensis* |
| Cottonwood | *Populus deltoides* |
| Black willow | *Salix niger* |
| Wheat | |
| Milo | |
| Haygrazer | |
| Hickory | *Carya sp.* |

*Wetland Associations*

| | |
|---|---|
| Hardstem bulrush | *Scirpus acutus* |
| Southern bulrush | *Scirpus californicus* |
| Common threesquare | *Scirpus americanus* |
| Common spikerush | *Eleocharis palustris* |
| Broadleaf cattail | *Typha latifolia* |
| Eastern burreed | *Sparganium americanum* |
| Wild millet | *Echinochloa crusgalli* |
| Lake sedge | *Carex riparia* |
| Nodding smartweed | *Polygonum lapathifolium* |
| Floating waterprimrose | *Jussiaea repens* |
| Marsh-purslane | *Ludwigia palustris* |
| Spatterdock | *Nuphar luteum* |
| American lotus | *Nelumbo lutea* |
| Broadleaf arrowhead | *Sagittaria latifolia* |
| Muskgrass | *Chara sp.* |
| Coontail | *Ceratophyllum demersum* |
| Southern naid | *Najas quadalupensis* |
| Little duckweeds | *Lemna sp.* |
| Slender pondweed | *Potamogeton pusillus* |

| | |
|---|---|
| Floating pondweed | _Potamogeton natans_ |
| Bigleaf pondweed | _Potamogeton amplifolius_ |

APPENDIX B

LIST OF BIRDS AND MAMMALS COMMONLY OBSERVED IN

THE STILLWATER CREEK WATERSHED

| COMMON NAME | SCIENTIFIC NAME |
|---|---|
| **Mammals** | |
| Opossum | *Didelphis marsupialis* |
| Eastern mole | *Scalopus aquaticus* |
| Eastern pipistrel | *Pipistrellus subflavus* |
| Mexican freetail bat | *Tadarida brasiliensis* |
| Raccoon | *Procyon lotor* |
| Striped skunk | *Mephitis mephitis* |
| Coyote | *Canis latrans* |
| Thirteen-lined ground squirrel | *Citellus tridecemlineatus* |
| Eastern gray squirrel | *Sciurus carolinensis* |
| Eastern fox squirrel | *Sciurus niger* |
| Plains pocket gopher | *Geomys busarius* |
| Plains pocket mouse | *Perognathus flavescens* |
| Fulvous harvest mouse | *Reithrodontomys flavescens* |
| Deer mouse | *Peromyscus maniculatus* |
| White-footed mouse | *Peromyscus leucopus* |
| Eastern woodrat | *Neotoma floridana* |
| Hispid cotton rat | *Sigmodon hispidus* |
| Muskrat | *Ondontia zibethica* |
| Blacktail jackrabbit | *Lepus californicus* |
| Eastern cottontail | *Sylvilagus floridanus* |
| Whitetail deer | *Odocoileus virginianum* |
| **Birds** | |
| Pied-billed grebe | *Podilymbus podiceps* |

| | |
|---|---|
| Double-crested cormorant | Phalacrocorax auritus |
| Canada goose | Branta canadensis |
| White-fronted goose | Anser albifrons |
| Snow/blue goose | Chen hyperborea |
| Mallard | Anas platyrhynchos |
| Pintail | Anas acuta |
| Gadwall | Anas strepera |
| American widgeon | Marcea americana |
| Shoveler | Spatula clypeata |
| Blue-winged teal | Anas discors |
| Green-winged teal | Anas carolinensis |
| Wood duck | Aix sponsa |
| Redhead | Aythya americana |
| Canvasback | Aythya valisineria |
| Ring-necked duck | Aythya collaris |
| Lesser scaup | Aytha affinis |
| Common goldeneye | Bucephala clangula |
| Bufflehead | Bucephala albeola |
| Ruddy duck | Oxyura jamaicensis |
| Common merganser | Mergus merganser |
| Hooded merganser | Lophodytes cucullatus |
| Turkey vulture | Cathartes aura |
| Marsh hawk | Cercus cyaneus |
| Red-tailed hawk | Buteo jamaicensis |
| Swainson's hawk | Buteo swainsoni |
| Sparrow hawk | Falco sparverius |
| Turkey | Meleagris gallopavo |

| | |
|---|---|
| Bobwhite | *Colinus virginianus* |
| Great blue heron | *Ardea herodias* |
| Green heron | *Butorides virescens* |
| Virginia rail | *Rallus limicola* |
| Sora | *Porzana carolina* |
| American coot | *Fulica americana* |
| Killdeer | *Charadrius vociferus* |
| Upland plover | *Bartramia longicauda* |
| Spotted sandpiper | *Actitis macularia* |
| Lesser yellowlegs | *Totanus flavipes* |
| Least sandpiper | *Erolia minutilla* |
| Common snipe | *Capella gallinago* |
| Franklin's gull | *Larus pipicans* |
| Mourning dove | *Zenaidura macroura* |
| Yellow-billed cuckoo | *Coccyzus americanus* |
| Roadrunner | *Geococcyx californianus* |
| Screech owl | *Otus asio* |
| Great horned owl | *Bubo virginianus* |
| Barred owl | *Strix varia* |
| Common nighthawk | *Chordeiles minor* |
| Chimney swift | *Chaetura pelagiea* |
| Belted kingfisher | *Megaceryle alcyar* |
| Yellow-shafted flicker | *Colaptes auratus* |
| Red-bellied woodpecker | *Centurus carolinus* |
| Downy woodpecker | *Dendrocopos pubescens* |
| Scissor-tailed flycatcher | *Muscivora forficata* |
| Eastern kingbird | *Tyrannus tyrannus* |

| | |
|---|---|
| Western kingbird | *Tyrannus verticalis* |
| Horned lark | *Eremophila alpestris* |
| Barn swallow | *Hirundo rustica* |
| Purple martin | *Progue subis* |
| Blue jay | *Cyanocitta cristata* |
| Common crow | *Corvus brachyrhynchos* |
| Carolina chickadee | *Parus carolinensis* |
| Tufted titmouse | *Parus bicolor* |
| White-breasted nuthatch | *Sitta carolinensis* |
| Brown creeper | *Certhia familiaris* |
| Carolina wren | *Thryothorus ludovicianus* |
| Mocking bird | *Mimus polyglottos* |
| Brown thrasher | *Toxostoma rufum* |
| Robin | *Turdus migratorius* |
| Eastern bluebird | *Sialia sialis* |
| Cedar waxwing | *Bombycilla cedrorum* |
| Loggerhead shrike | *Lanius ludovicianus* |
| Starling | *Sturnus vulgaris* |
| Red-eyed vireo | *Vireo olivaceus* |
| Yellowthroat | *Geothlypis trichos* |
| House sparrow | *Passer domesticus* |
| Eastern meadowlark | *Sturnella magna* |
| Red-winged blackbird | *Agelaius phoeniceus* |
| Boat-tailed grackle | *Cassidix mexicanus* |
| Common grackle | *Quiscalus quiscula* |
| Brown-headed cowbird | *Molothrus ater* |
| Orchard oriole | *Icterus spurius* |

| | |
|---|---|
| Baltimore oriole | *Icterus galbula* |
| Cardinal | *Richmondena cardinaelis* |
| Indigo bunting | *Passerina cyanea* |
| Painted bunting | *Passerina ciris* |
| American goldfinch | *Spinus tristis* |
| Dickcissel | *Spiza americana* |
| Grasshopper sparrow | *Amnodramus savannarum* |
| Slate-colored junco | *Junco hyemalis* |
| Chipping sparrow | *Spizella passerina* |
| Field sparrow | *Spizella pusilla* |
| Song sparrow | *Melospira melodia* |

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* Nomenclature based on AOU Checklist of North American Birds, 5th ed., and on G. S. Miller and R. Kellog List of North American Recent Mammals, U. S. Natl. Mus. Bull. 205. 1955.

# APPENDIX C

# DATA CARD INFORMATION

SD - STATIC DECK

| Column Code | Information |
|---|---|
| 1-6 | Impoundment ID Number |
| 7 | Size Category |
| 8-13 | Actual Size of Impoundment |
| 14 | Orientation of Dam |
| 15 | Visibility from Roadway |
| 16 | Land Use of Watershed |
| 17 | Surrounding Topography |
| 18 | Extent of Livestock Grazing |
| 19 | Erosion Conditions |
| 20 | Shoreline Development Index |
| 21 | Maximum Depth-Surface Relation |
| 22 | Cattle Activity at Edge |
| 23 | Distance to Major Food Crops |
| 24 | Distance to Human Dwellings |
| 25 | Distance to Section Road |
| 26 | Distance to Major Impoundment |
| 27 | Ownership |
| 28 | Degree of Habitat Management |
| 29 | Extent of Human Disturbance |
| 30 | Degree of Land Posting |
| 31 | Water Level in the Fall |
| 32 | Water Level in the Winter |

## SD - STATIC DECK (CONTINUED)

| Column Code | Information |
|---|---|
| 33 | Water Level in the Spring |
| 34 | Presence of Exposed Margins |
| 35 | Fall Vegetation Index |
| 36 | Winter Vegetation Index |
| 37 | Spring Vegetation Index |
| 38 | Fall Macroinvertebrates |
| 39 | Winter Macroinvertebrates |
| 40 | Spring Macroinvertebrates |
| 41 | Fall Turbidity |
| 42 | Winter Turbidity |
| 43 | Spring Turbidity |
| 44 | Fall Alkalinity Types |
| 45 | Winter Alkalinity Types |
| 46 | Spring Alkalinity Types |
| 47-51 | Fall Alkalinity in PPM |
| 52-56 | Winter Alkalinity in PPM |
| 57-61 | Spring Alkalinity in PPM |

## OB - OBSERVATION DECK

| | |
|---|---|
| 1-6 | Impoundment ID number |
| 7-9 | Season and Week Number |
| 10 | General Weather Situation |
| 11 | Visibility |
| 12 | Air Temperature |
| 13 | Wind Direction |

OB - OBSERVATION DECK (CONTINUED)

| Column Code | Information |
|---|---|
| 14 | Average Wind Speed |
| 15 | Wind Chill Index |
| 16 | Percent of Cloud Cover |
| 17 | Current Precipitation |
| 18 | Past Precipitation |
| 19 | Barometric Pressure |
| 20 | Distance Behind Major Front |
| 21 | Distance Ahead Major Front |
| 22 | Blank |
| 23 | Percent of Ice Cover |
| 24 | Time of Observation |
| 25-28 | Number of Mallards |
| 29-32 | Number of Gadwalls |
| 33-36 | Number of Wigeon |
| 37-39 | Number of Green-winged Teal |
| 40-42 | Number of Blue-winged Teal |
| 43-45 | Number of Shoveler |
| 46-48 | Number of Pintail |
| 49-51 | Number of Ring-neck |
| 52-54 | Number of Redhead |
| 55-57 | Number of Scaup |
| 58-60 | Number of Canvasback |
| 61-63 | Number of Ruddy Ducks |
| 64-66 | Number of Snow/Blue Geese |
| 67-68 | Number of Canada Geese |

OB - OBSERVATION DECK (CONTINUED)

| Column Code | Information |
|---|---|
| 69-70 | Number of White-fronted Geese |
| 71-72 | Number of Bufflehead |
| 73 | Number of Hooded Mergansers |
| 74 | Number of Black Duck |
| 75 | Number of Wood Duck |
| 76 | Number of Swans |
| 77 | Number of American Goldeneye |
| 78-80 | Number of Common Mergansers |

TD - TOTALS DECK

| | |
|---|---|
| 1-6 | Impoundment ID Number |
| 7 | Season |
| 8 | Size Category |
| 9 | Location of Dam |
| 10 | Visibility from Roadway |
| 11 | Land Use of Watershed |
| 12 | Surrounding Topography |
| 13 | Extent of Livestock Grazing |
| 14 | Erosion Conditions |
| 15 | Shoreline Development Index |
| 16 | Maximum Depth-Surface Relation |
| 17 | Cattle Activity at Edge |
| 18 | Distance to Major Food Crops |
| 19 | Distance to Human Dwellings |
| 20 | Distance to Section Road |

TD - TOTALS DECK (CONTINUED)

| Column Code | Information |
|---|---|
| 21 | Distance to Major Impoundment |
| 22 | Ownership |
| 23 | Degree of Habitat Management |
| 24 | Extent of Human Disturbance |
| 25 | Degree of Land Posting |
| 26 | Blank |
| 27-32 | Total Number of Waterfowl Observed per Season |
| 33-44 | Variance of Waterfowl Observed per Season |
| 45-50 | Acreage of Impoundment |
| 53-54 | Number of Observations per Season |

# APPENDIX D

## ANALYSIS OF VARIANCE TABLES AND SEASONAL CELL MEANS FOR STATIC AND DYNAMIC HABITAT CHARACTERISTICS

TABLE XV

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO IMPOUNDMENT SIZE

Seasonal and Overall Means

| Season | Size Category | n[a] | NWFL[b] |
|---|---|---|---|
| Fall | 1 (0.0405-0.405 ha.) | 47 | 1.42 |
| | 2 (0.406-4.05 ha.) | 46 | 0.58 |
| | 3 (4.06-40.50 ha.) | 3 | 0.00 |
| | 4 (40.60-200.0 ha.) | 3 | 1.73 |
| | 5 (> 200.0 ha.) | 1 | 0.57 |
| Winter | 1 | 47 | 4.56 |
| | 2 | 46 | 1.28 |
| | 3 | 3 | 0.00 |
| | 4 | 3 | 1.64 |
| | 5 | 1 | 0.29 |
| Spring | 1 | 47 | 5.93 |
| | 2 | 46 | 1.92 |
| | 3 | 3 | 0.00 |
| | 4 | 3 | 1.70 |
| | 5 | 1 | 0.08 |
| Overall | 1 | 141 | 3.97 |
| | 2 | 138 | 1.26 |
| | 3 | 9 | 0.00 |
| | 4 | 9 | 1.69 |
| | 5 | 3 | 0.31 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 95 | 8673.54 | 91.30 | | |
| Size | 4 | 592.87 | 148.22 | 2.91 | .975 |
| Season | 2 | 384.21 | 192.10 | 3.77 | .975 |
| Interaction | 8 | 159.82 | 19.98 | < 0 | - |
| Residual | 190 | 9690.29 | 51.00 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

[a] n is the number of impoundments intensively surveyed within each characteristic category

[b] NWFL is the mean number of waterfowl observed per surface acre

TABLE XVI

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO ORIENTATION OF DAM

Seasonal and Overall Means

| Season | Dam Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (North) | 17 | 1.28 |
| | 2 (East) | 22 | 0.20 |
| | 3 (South) | 34 | 1.50 |
| | 4 (West) | 27 | 0.81 |
| Winter | 1 | 17 | 1.96 |
| | 2 | 22 | 1.34 |
| | 3 | 34 | 5.11 |
| | 4 | 27 | 1.55 |
| Spring | 1 | 17 | 2.56 |
| | 2 | 22 | 0.60 |
| | 3 | 34 | 4.20 |
| | 4 | 27 | 6.38 |
| Overall | 1 | 51 | 1.93 |
| | 2 | 66 | 0.72 |
| | 3 | .02 | 3.60 |
| | 4 | 81 | 2.92 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 96 | 8901.35 | 92.72 | | |
| Dam | 3 | 365.07 | 121.69 | 2.47 | .90 |
| Season | 2 | 384.21 | 192.10 | 3.89 | .975 |
| Interaction | 6 | 378.73 | 63.12 | 1.28 | NS |
| Residual | 192 | 9472.02 | 49.33 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XVII

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO VISIBILITY FROM ROADWAY

Seasonal and Overall Means

| Season | Visibility Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (Visible) | 69 | 0.99 |
| | 2 (Not Visible) | 31 | 1.00 |
| Winter | 1 | 69 | 3.51 |
| | 2 | 31 | 4.20 |
| Spring | 1 | 69 | 2.58 |
| | 2 | 31 | 3.23 |
| Overall | 1 | 207 | 2.36 |
| | 2 | 93 | 2.81 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 98 | 9253.32 | 94.42 | | |
| Visibility | 1 | 13.10 | 13.10 | $<0$ | - |
| Season | 2 | 384.21 | 192.10 | 3.82 | .975 |
| Interaction | 2 | 6.21 | 3.11 | $<0$ | - |
| Residual | 196 | 9844.53 | 50.23 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XVIII

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO LAND USE OF SURROUNDING WATERSHED

Seasonal and Overall Means

| Season | Land Use Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (Human Habitation) | 16 | 0.31 |
| | 2 (Crops/Farm Land) | 68 | 0.85 |
| | 3 (Crops/Grazing) | 12 | 0.76 |
| | 4 (Oil Field) | 1 | 0.00 |
| | 5 (Idle) | 3 | 9.26 |
| Winter | 1 | 16 | 0.23 |
| | 2 | 68 | 2.80 |
| | 3 | 12 | 6.45 |
| | 4 | 1 | 0.00 |
| | 5 | 3 | 2.20 |
| Spring | 1 | 16 | 3.50 |
| | 2 | 68 | 4.05 |
| | 3 | 12 | 3.38 |
| | 4 | 1 | 0.00 |
| | 5 | 3 | 0.00 |
| Overall | 1 | 48 | 1.35 |
| | 2 | 204 | 2.57 |
| | 3 | 36 | 3.53 |
| | 4 | 3 | 0.00 |
| | 5 | 9 | 3.82 |

Source — Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 95 | 9129.44 | 96.10 | | |
| Land Use | 4 | 136.98 | 34.25 | <0 | - |
| Season | 2 | 384.20 | 192.10 | 3.87 | .975 |
| Interaction | 8 | 417.20 | 52.15 | 1.05 | NS |
| Residual | 190 | 9433.54 | 49.65 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XIX

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO SURROUNDING TOPOGRAPHY

Seasonal and Overall Means

| Season | Topography Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (Open) | 60 | 0.72 |
| | 2 (Semi-closed) | 28 | 1.00 |
| | 3 (Closed) | 12 | 2.34 |
| Winter | 1 | 60 | 2.04 |
| | 2 | 28 | 5.33 |
| | 3 | 12 | 0.55 |
| Spring | 1 | 60 | 4.08 |
| | 2 | 28 | 4.54 |
| | 3 | 12 | 0.01 |
| Overall | 1 | 180 | 2.28 |
| | 2 | 84 | 3.62 |
| | 3 | 36 | 0.97 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 97 | 9067.05 | 93.47 | | |
| Topography | 2 | 199.37 | 99.68 | 2.02 | .750 |
| Season | 2 | 384.21 | 192.10 | 3.90 | .975 |
| Interaction | 4 | 293.84 | 73.46 | 1.49 | .750 |
| Residual | 194 | 9556.91 | 49.26 | | |
| Corrected Total | 299 | 19501.36 | 65.22 | | |

TABLE XX

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO EXTENT OF LIVESTOCK GRAZING

Seasonal and Overall Means

| Season | Grazing Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (None) | 9 | 3.60 |
| | 2 (Lightly Overgrazed) | 21 | 0.71 |
| | 3 (Overgrazed) | 32 | 0.98 |
| | 4 (Heavily Overgrazed) | 38 | 0.55 |
| Winter | 1 | 9 | 1.11 |
| | 2 | 21 | 1.23 |
| | 3 | 32 | 3.52 |
| | 4 | 38 | 3.41 |
| Spring | 1 | 9 | 5.46 |
| | 2 | 21 | 1.23 |
| | 3 | 32 | 3.52 |
| | 4 | 38 | 3.41 |
| Overall | 1 | 27 | 3.39 |
| | 2 | 63 | 1.92 |
| | 3 | 96 | 3.13 |
| | 4 | 114 | 2.07 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 96 | 9164.89 | 95.47 | | |
| Grazing | 3 | 101.53 | 33.84 | $<0$ | - |
| Season | 2 | 384.21 | 192.10 | 3.83 | .975 |
| Interaction | 6 | 228.40 | 38.07 | $<0$ | - |
| Residual | 192 | 9622.34 | 50.12 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XXI

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO EROSION CONDITIONS

Season and Overall Means

| Season | Erosion Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (No Erosion) | 8 | 1.28 |
| | 2 (Light) | 35 | 1.45 |
| | 3 (Moderate) | 40 | 0.63 |
| | 4 (Severe) | 17 | 0.77 |
| Winter | 1 | 8 | 0.14 |
| | 2 | 35 | 2.17 |
| | 3 | 40 | 4.20 |
| | 4 | 17 | 1.95 |
| Spring | 1 | 8 | 8.18 |
| | 2 | 35 | 3.15 |
| | 3 | 40 | 4.11 |
| | 4 | 17 | 1.88 |
| Overall | 1 | 24 | 3.20 |
| | 2 | 105 | 2.25 |
| | 3 | 120 | 2.98 |
| | 4 | 51 | 1.53 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 96 | 9172.87 | 95.55 | | |
| Erosion | 3 | 93.55 | 31.18 | $<0$ | - |
| Season | 2 | 384.21 | 192.10 | 3.87 | .975 |
| Interaction | 6 | 316.25 | 52.71 | 1.06 | NS |
| Residual | 192 | 9534.49 | 49.66 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

# TABLE XXII

## MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO SHORELINE DEVELOPMENT INDEX

Seasonal and Overall Means

| Season | Development Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (Round) | 54 | 1.43 |
| | 2 (Moderate) | 38 | 0.43 |
| | 3 (Extensive) | 8 | 0.72 |
| Winter | 1 | 54 | 4.18 |
| | 2 | 38 | 1.22 |
| | 3 | 8 | 0.75 |
| Spring | 1 | 54 | 5.74 |
| | 2 | 38 | 1.41 |
| | 3 | 8 | 1.11 |
| Overall | 1 | 162 | 3.78 |
| | 2 | 114 | 1.02 |
| | 3 | 24 | 0.86 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 97 | 8686.04 | 89.55 | | |
| Development | 2 | 580.38 | 290.19 | 5.80 | .995 |
| Season | 2 | 384.21 | 192 10 | 3.84 | .975 |
| Interaction | 4 | 150.62 | 37.66 | $< 0$ | - |
| Residual | 194 | 9700.12 | 50.00 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XXIII

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO MAXIMUM DEPTH-SURFACE RELATION

Seasonal and Overall Means

| Season | Depth-Surface Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (Low) | 26 | 0.57 |
| | 2 (Moderate) | 49 | 1.41 |
| | 3 (High) | 25 | 0.63 |
| Winter | 1 | 26 | 7.20 |
| | 2 | 49 | 1.40 |
| | 3 | 25 | 0.90 |
| Spring | 1 | 26 | 6.99 |
| | 2 | 49 | 2.87 |
| | 3 | 25 | 2.00 |
| Overall | 1 | 78 | 4.92 |
| | 2 | 147 | 1.89 |
| | 3 | 75 | 1.17 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 97 | 8624.42 | 88.91 | | |
| Depth-Surface | 2 | 642.00 | 321.00 | 6.63 | .995 |
| Season | 2 | 384.21 | 192.10 | 3.96 | .975 |
| Interaction | 4 | 451.18 | 112.79 | 2.33 | .900 |
| Residual | 194 | 9399.57 | 48.45 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XXIV

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO CATTLE ACTIVITY AT EDGE

Seasonal and Overall Means

| Season | Cattle Activity Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (None) | 25 | 1.49 |
| | 2 (Light) | 40 | 0.78 |
| | 3 (Extensive) | 35 | 0.88 |
| Winter | 1 | 25 | 2.34 |
| | 2 | 40 | 2.69 |
| | 3 | 35 | 3.20 |
| Spring | 1 | 25 | 2.93 |
| | 2 | 40 | 5.29 |
| | 3 | 35 | 2.49 |
| Overall | 1 | 75 | 2.26 |
| | 2 | 120 | 2.92 |
| | 3 | 105 | 2.19 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 97 | 9230.83 | 95.16 | | |
| Cattle Activity | 2 | 35.58 | 17.79 | <0 | - |
| Season | 2 | 384.21 | 192.10 | 3.84 | .975 |
| Interaction | 4 | 150.27 | 37.57 | <0 | - |
| Residual | 194 | 9700.47 | 50.00 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XXV

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO DISTANCE TO MAJOR FOOD CROPS

Seasonal and Overall Means

| Season | Distance to Crops Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (< 0.4 km.) | 16 | 1.16 |
| | 2 (0.4 - 0.8 km.) | 40 | 0.80 |
| | 3 (0.8 - 1.6 km.) | 28 | 1.60 |
| | 4 (> 1.6 km. ) | 16 | 0.26 |
| Winter | 1 | 16 | 4.36 |
| | 2 | 40 | 4.02 |
| | 3 | 28 | 1.28 |
| | 4 | 16 | 0.72 |
| Spring | 1 | 16 | 3.65 |
| | 2 | 40 | 4.90 |
| | 3 | 28 | 1.95 |
| | 4 | 16 | 3.93 |
| Overall | 1 | 48 | 3.06 |
| | 2 | 120 | 3.24 |
| | 3 | 84 | 1.61 |
| | 4 | 48 | 1.63 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 96 | 9082.81 | 94.61 | | |
| Distance to Crops | 3 | 183.61 | 61.20 | $<0$ | - |
| Season | 2 | 384.21 | 192.10 | 3.83 | .975 |
| Interaction | 6 | 214.55 | 35.76 | $<0$ | - |
| Residual | 192 | 9636.20 | 50.19 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XXVI

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO DISTANCE TO HUMAN DWELLINGS

Seasonal and Overall Means

| Season | Dwellings Distance Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (< 0.4 km. ) | 30 | 0.53 |
| | 2 (0.4 - 0.8 km.) | 28 | 1.32 |
| | 3 (0.8 - 1.6 km.) | 29 | 1.46 |
| | 4 (> 1.6 km.) | 13 | 0.32 |
| Winter | 1 | 30 | 2.65 |
| | 2 | 28 | 3.35 |
| | 3 | 29 | 3.40 |
| | 4 | 13 | 0.46 |
| Spring | 1 | 30 | 3.12 |
| | 2 | 28 | 1.73 |
| | 3 | 29 | 6.47 |
| | 4 | 13 | 3.29 |
| Overall | 1 | 90 | 2.10 |
| | 2 | 84 | 2.13 |
| | 3 | 87 | 3.78 |
| | 4 | 39 | 1.36 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 96 | 9047.75 | 94.25 | | |
| Distance to Dwellings | 3 | 218.66 | 72.89 | < 0 | - |
| Season | 2 | 384.21 | 192.10 | 3.84 | .975 |
| Interaction | 6 | 237.06 | 39.51 | < 0 | - |
| Residual | 192 | 9613.68 | 50.07 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XXVII

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO DISTANCE TO SECTION ROAD

Seasonal and Overall Means

| Season | Section Road Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (< 0.4 km.) | 43 | 1.34 |
| | 2 (0.4 - 0.8 km.) | 39 | 1.04 |
| | 3 (0.8 - 1.6 km.) | 17 | 0.07 |
| | 4 (> 1.6 km.) | 1 | 0.00 |
| Winter | 1 | 43 | 4.40 |
| | 2 | 39 | 1.91 |
| | 3 | 17 | 0.87 |
| | 4 | 1 | 0.00 |
| Spring | 1 | 43 | 4.86 |
| | 2 | 39 | 3.85 |
| | 3 | 17 | 0.77 |
| | 4 | 1 | 0.00 |
| Overall | 1 | 129 | 3.53 |
| | 2 | 117 | 2.26 |
| | 3 | 51 | 0.57 |
| | 4 | 3 | 0.00 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 96 | 8914.56 | 92.86 | | |
| Section Road | 3 | 351.86 | 117.29 | 2.31 | .900 |
| Season | 2 | 384.21 | 192.10 | 3.78 | .975 |
| Interaction | 6 | 98.42 | 16.40 | $<0$ | - |
| Residual | 192 | 9752.32 | 50.79 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XXVIII

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO DISTANCE TO MAJOR IMPOUNDMENTS

Seasonal and Overall Means

| Season | DTMI Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (< 0.4 km.) | 4 | 1.44 |
| | 2 (0.4 - 1.6 km.) | 12 | 3.48 |
| | 3 (1.6 - 5.0 km.) | 36 | 0.57 |
| | 4 (5.0 - 10.0 km.) | 28 | 1.08 |
| | 5 (10.0 - 16.0 km.) | 9 | 0.14 |
| | 6 (> 16.0 km.) | 11 | 0.00 |
| Winter | 1 | 4 | 1.30 |
| | 2 | 12 | 8.21 |
| | 3 | 36 | 3.62 |
| | 4 | 28 | 0.63 |
| | 5 | 9 | 2.94 |
| | 6 | 11 | 0.00 |
| Spring | 1 | 4 | 1.30 |
| | 2 | 12 | 10.54 |
| | 3 | 36 | 3.11 |
| | 4 | 28 | 4.29 |
| | 5 | 9 | 0.47 |
| | 6 | 11 | 0.39 |
| Overall | 1 | 12 | 1.35 |
| | 2 | 36 | 7.41 |
| | 3 | 108 | 2.43 |
| | 4 | 84 | 2.00 |
| | 5 | 27 | 1.18 |
| | 6 | 33 | 0.13 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 94 | 8129.11 | 86.48 | | |
| Distance to Major Impoundments | 5 | 1137.31 | 227.46 | 4.52 | .995 |
| Season | 2 | 384.21 | 192.10 | 3.82 | .975 |
| Interaction | 10 | 385.02 | 38.50 | < 0 | - |
| Residual | 188 | 9465.72 | 50.35 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XXIX

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO OWNERSHIP

Seasonal and Overall Means

| Season | Ownership Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (Private) | 17 | 0.30 |
| | 2 (Government) | 83 | 1.14 |
| Winter | 1 | 17 | 1.75 |
| | 2 | 83 | 2.99 |
| Spring | 1 | 17 | 0.56 |
| | 2 | 83 | 4.37 |
| Overall | 1 | 51 | 0.87 |
| | 2 | 249 | 2.99 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 98 | 9102.51 | 92.88 | | |
| Ownership | 1 | 163.90 | 163.90 | 3.29 | .900 |
| Season | 2 | 384.21 | 192.10 | 3.85 | .975 |
| Interaction | 2 | 73.32 | 36.66 | $< 0$ | - |
| Residual | 192 | 9777.42 | 49.88 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XXX

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO DEGREE OF HABITAT MANAGEMENT

Seasonal and Overall Means

| Season | Habitat Management Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (Leased, Managed) | 2 | 1.95 |
| | 2 (Leased, Not Managed) | 5 | 1.29 |
| | 3 (None) | 93 | 0.96 |
| | 1 | 6 | 1.98 |
| | 2 | 15 | 5.23 |
| | 3 | 279 | 2.36 |
| | 1 | 2 | 0.96 |
| | 2 | 5 | 2.29 |
| | 3 | 93 | 9.00 |
| | 1 | 6 | 1.98 |
| | 2 | 15 | 5.23 |
| | 3 | 279 | 2.36 |

Analysis of Variance

| Source | df | Sum of Square | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 97 | 9147.48 | 94.30 | | |
| Habitat Management | 2 | 118.94 | 59.47 | 1.18 | NS |
| Season | 2 | 384.21 | 192.10 | 3.81 | .975 |
| Interaction | 4 | 70.99 | 17.75 | $<0$ | - |
| Residual | 194 | 9779.76 | 50.41 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XXXI

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO EXTENT OF HUMAN DISTURBANCE

Seasonal and Overall Means

| Season | Human Disturbance Category | n | NWFL |
|---|---|---|---|
| Fall | 2 (Slight) | 22 | 1.39 |
| | 3 (Moderate) | 30 | 1.09 |
| | 4 (Heavy) | 48 | 0.75 |
| Winter | 2 | 22 | 3.05 |
| | 3 | 30 | 2.18 |
| | 4 | 48 | 3.03 |
| Spring | 2 | 22 | 1.46 |
| | 3 | 30 | 4.87 |
| | 4 | 48 | 4.04 |
| Overall | 2 | 66 | 1.97 |
| | 3 | 90 | 2.72 |
| | 4 | 144 | 2.61 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 97 | 9241.89 | 95.28 | | |
| Human Disturbance | 2 | 24.53 | 12.26 | $<0$ | - |
| Season | 2 | 384.21 | 192.10 | 3.84 | .975 |
| Interaction | 4 | 154.40 | 38.60 | $<0$ | - |
| Residual | 194 | 9696.34 | 49.98 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XXXII

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO DEGREE OF LAND POSTING

Seasonal and Overall Means

| Season | Land Posting Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (Posted) | 85 | 1.10 |
| | 2 (Not Posted) | 15 | 0.40 |
| Winter | 1 | 85 | 2.49 |
| | 2 | 15 | 4.45 |
| Spring | 1 | 85 | 3.53 |
| | 2 | 15 | 4.83 |
| Overall | 1 | 255 | 2.37 |
| | 2 | 45 | 3.23 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 98 | 9238.34 | 94.27 | | |
| Land Posting | 1 | 28.07 | 28.07 | $<0$ | - |
| Season | 2 | 384.21 | 192.10 | 3.84 | .975 |
| Interaction | 2 | 48.98 | 24.49 | $<0$ | - |
| Residual | 196 | 9801.76 | 50.01 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XXXIII

MEAN NWFL VALUES AND AOV FOR EFFECT DUE TO PRESENCE OF EXPOSED SHORELINE MARGIN

Seasonal and Overall Means

| Season | Shoreline Margin Category | n | NWFL |
|---|---|---|---|
| Fall | 1 (Present) | 64 | 1.24 |
| | 2 (Not Present) | 36 | 0.55 |
| Winter | 1 | 64 | 3.49 |
| | 2 | 36 | 1.52 |
| Spring | 1 | 64 | 3.56 |
| | 2 | 36 | 4.01 |
| Overall | 1 | 192 | 2.76 |
| | 2 | 108 | 2.03 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
|---|---|---|---|---|---|
| Total | 98 | 9228.85 | 94.17 | | |
| Shoreline Margin | 1 | 37.56 | 37.56 | $<0$ | - |
| Season | 2 | 384.21 | 192.10 | 3.85 | .975 |
| Interaction | 2 | 67.02 | 33.51 | $<0$ | - |
| Residual | 196 | 9783.72 | 49.92 | | |
| Corrected Total | 299 | 19501.37 | 65.22 | | |

TABLE XXXIV

FALL SEASONAL MEANS AND AOV FOR EFFECT DUE TO DYNAMIC HABITAT CHARACTERISTICS

Overall Means

| Characteristic | - Category | n | NWFL |
|---|---|---|---|
| Turbidity | 1 (Clear) | 29 | 0.66 |
| | 2 (Intermediate) | 34 | 1.33 |
| | 3 (Turbid) | 38 | 0.92 |
| Alkalinity | 1 (< 50 ppm) | 41 | 0.45 |
| | 2 (50 - 150 ppm) | 58 | 1.25 |
| | 3 (> 150 ppm) | 2 | 4.28 |
| Aquatic vegetation | 1 (High, > 10.0) | 76 | 1.13 |
| | 2 (Moderate, 1.0 - 10.0) | 20 | 0.22 |
| | 3 (Low, < 1.0) | 5 | 1.86 |
| Macroin-vertebrates | 1 (Low, < 500 Macroforms) | 66 | 0.74 |
| | 2 (High, > 500 Macroforms) | 35 | 1.45 |
| Water Level | 1 (Below Normal) | 68 | 1.01 |
| | 2 (Normal) | 33 | 0.74 |
| | 3 (Above Normal) | 0 | |

Characteristic x Characteristic Means

| Characteristic - | Category | Characteristic - | Category | n | NWFL |
|---|---|---|---|---|---|
| Turbidity | 1 | Alkalinity | 1 | 9 | 0.00 |
| | | | 2 | 19 | 0.56 |
| | | | 3 | 4 | 8.33 |
| | 2 | | 1 | 8 | 0.07 |
| | | | 2 | 28 | 1.78 |
| | | | 3 | 3 | 0.23 |
| | 3 | | 1 | 13 | 0.75 |
| | | | 2 | 14 | 1.22 |
| | | | 3 | 2 | 0.00 |
| Macroinverte-brates | 1 | Alkalinity | 1 | 24 | 0.47 |
| | | | 2 | 34 | 0.99 |
| | | | 3 | 3 | 0.00 |

TABLE XXXIV (Continued)

| Characteristic - | Category | Characteristic - | Category | n | NWFL |
|---|---|---|---|---|---|
| Macroinvertebrates | 2 | Alkalinity | 1 | 6 | 0.39 |
| | | | 2 | 27 | 1.61 |
| | | | 3 | 6 | 4.28 |
| Aquatic Vegetation | 1 | Alkalinity | 1 | 22 | 0.44 |
| | | | 2 | 44 | 1.52 |
| | | | 3 | 5 | 4.28 |
| | 2 | | 1 | 6 | 0.00 |
| | | | 2 | 14 | 0.32 |
| | | | 3 | 2 | 0.00 |
| | 3 | | 1 | 2 | 1.95 |
| | | | 2 | 3 | 1.80 |
| | | | 3 | 2 | 0.00 |
| Water Level | 1 | Alkalinity | 1 | 24 | 0.48 |
| | | | 2 | 37 | 1.50 |
| | | | 3 | 7 | 4.28 |
| | 2 | | 1 | 6 | 0.37 |
| | | | 2 | 24 | 0.89 |
| | | | 3 | 2 | 0.00 |
| Macroinvertebrates | 1 | Turbidity | 1 | 13 | 0.27 |
| | | | 2 | 23 | o.59 |
| | | | 3 | 30 | 1.05 |
| | 2 | | 1 | 16 | 0.97 |
| | | | 2 | 11 | 2.87 |
| | | | 3 | 8 | 0.45 |
| Aquatic Vegetation | 1 | Turbidity | 1 | 17 | 0.78 |
| | | | 2 | 25 | 1.62 |
| | | | 3 | 34 | 0.93 |
| | 2 | | 1 | 11 | 0.20 |
| | | | 2 | 6 | 0.39 |
| | | | 3 | 3 | 0.00 |
| | 3 | | 1 | 1 | 3.54 |
| | | | 2 | 3 | 0.81 |
| | | | 3 | 1 | 3.32 |
| Water Level | 1 | Turbidity | 1 | 15 | 0.77 |
| | | | 2 | 22 | 1.43 |
| | | | 3 | 31 | 1.03 |

TABLE XXXIV (Continued)

| Characteristic - Category | | Characteristic - Category | | n | NWFL |
|---|---|---|---|---|---|
| Water Level | 2 | Turbidity | 1 | 14 | 0.54 |
| | | | 2 | 12 | 1.14 |
| | | | 3 | 7 | 0.47 |
| Aquatic Vegetation | 1 | Macroinvertebrates | 1 | 52 | 0.86 |
| | | | 2 | 24 | 1.70 |
| | 2 | | 1 | 12 | 0.20 |
| | | | 2 | 8 | 0.27 |
| | 3 | | 1 | 2 | 0.82 |
| | | | 2 | 3 | 2.55 |
| Water Level | 1 | Macroinvertebrates | 1 | 47 | 0.75 |
| | | | 2 | 21 | 1.88 |
| | 2 | | 1 | 19 | 0.70 |
| | | | 2 | 14 | 0.81 |
| | 3 | | 1 | 0 | - |
| | | | 2 | 0 | - |
| Water Level | 1 | Aquatic Vegetation | 1 | 61 | 1.22 |
| | | | 2 | 6 | 0.00 |
| | | | 3 | 1 | 0.58 |
| | 2 | | 1 | 15 | 0.76 |
| | | | 2 | 14 | 0.32 |
| | | | 3 | 4 | 2.18 |
| | 3 | | 1 | 0 | - |
| | | | 2 | 0 | - |
| | | | 3 | 0 | - |

TABLE XXXIV (Continued)

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance |
|---|---|---|---|---|---|
| Corrected Total | 99 | 1105.70 | 11.17 | | |
| Water Level | 1 | 2.39 | 2.39 | < 0 | - |
| Aquatic Vegetation | 2 | 43.08 | 21.54 | 1.67 | .750 |
| Macroinvertebrates | 1 | 31.90 | 31.90 | 2.48 | .750 |
| Turbidity | 2 | 6.77 | 3.38 | 0 | - |
| Alkalinity | 2 | 94.94 | 47.47 | 3.68 | .900 |
| Water Level x Aquatic vegetation Interaction | 2 | 1.95 | 0.97 | < 0 | - |
| Water Level x Macroinvertebrates Interaction | 1 | 14.52 | 14.52 | 1.13 | NS |
| Water Level x Turbidity Interaction | 2 | 0.23 | 0.11 | < 0 | - |
| Water Level x Alkalinity Interaction | 1 | 2.23 | 2.23 | < 0 | - |
| Aquatic Vegetation x Macro-Invertebrates Interaction | 2 | 4.34 | 2.17 | < 0 | - |
| Aquatic Vegetation x Turbidity Interaction | 4 | 10.42 | 2.60 | < 0 | - |
| Aquatic Vegetation x Alkalinity Interaction | 2 | 5.28 | 2.64 | < 0 | - |
| Macroinvertebrate x Turbidity Interaction | 2 | 80.95 | 40.48 | 3.14 | .900 |
| Macroinvertebrate x Alkalinity Interaction | 1 | -6.18 | -6.18 | < 0 | - |
| Turbidity x Alkalinity Interaction | 3 | 114.96 | 38.32 | 2.97 | .900 |
| Residual | 71 | 915.48 | 12.89 | | |

TABLE XXXV

WINTER SEASONAL MEANS AND AOV FOR EFFECT DUE TO DYNAMIC HABITAT CHARACTERISTICS

Overall Means

| Characteristic | Category | n | NWFL |
|---|---|---|---|
| Turbidity | 1 (Clear) | 15 | 0.46 |
| | 2 (Intermediate) | 47 | 2.99 |
| | 3 (Turbid) | 38 | 3.15 |
| Alkalinity | 1 ( < 50 ppm) | 30 | 0.99 |
| | 2 (50 - 150 ppm) | 61 | 4.65 |
| | 3 ( > 150 ppm) | 9 | 6.89 |
| Aquatic Vegetation | 1 (High, > 10.0) | 86 | 2.73 |
| | 2 (Medium, 1.0 - 10.0) | 10 | 2.74 |
| | 3 (Low, < 1.0) | 4 | 1.30 |
| Macroin-vertebrates | 1 (Low, < 500 Macroforms) | 77 | 2.67 |
| | 2 (High, > 500 Macroforms) | 23 | 2.70 |
| Water Level | 1 (Below Normal) | 56 | 4.04 |
| | 2 (Normal) | 42 | 0.90 |
| | 3 (Above Normal) | 2 | 1.54 |

Characteristic x Characteristic Means

| Characteristic | Category | Characteristic | Category | n | NWFL |
|---|---|---|---|---|---|
| Turbidity | 1 | Alkalinity | 1 | 6 | 0.42 |
| | | | 2 | 15 | 0.54 |
| | | | 3 | 5 | 3.54 |
| | 2 | | 1 | 9 | 0.69 |
| | | | 2 | 31 | 4.56 |
| | | | 3 | 3 | 2.05 |
| | 3 | | 1 | 15 | 1.41 |
| | | | 2 | 15 | 6.92 |
| | | | 3 | 1 | 1.05 |
| Macro-Invertebrates | 1 | Alkalinity | 1 | 22 | 0.98 |
| | | | 2 | 40 | 5.17 |
| | | | 3 | 4 | 0.67 |

TABLE XXXV (Continued)

| Characteristic - Category | | Characteristic - Category | | n | NWFL |
|---|---|---|---|---|---|
| Macroinverte- | 2 | Alkalinity | 1 | 8 | 1.05 |
| | | | 2 | 21 | 3.58 |
| | | | 3 | 5 | 2.98 |
| Aquatic Vege- | 1 | Alkalinity | 1 | 22 | 0.98 |
| | | | 2 | 53 | 4.94 |
| | | | 3 | 5 | 3.28 |
| | 2 | | 1 | 6 | 0.77 |
| | | | 2 | 6 | 4.05 |
| | | | 3 | 2 | 1.02 |
| | 3 | | 1 | 2 | 1.71 |
| | | | 2 | 2 | 0.90 |
| | | | 3 | 2 | 0.95 |
| Water Level | 1 | Alkalinity | 1 | 16 | 1.31 |
| | | | 2 | 26 | 8.26 |
| | | | 3 | 6 | 1.05 |
| | 2 | | 1 | 12 | 0.33 |
| | | | 2 | 35 | 1.34 |
| | | | 3 | 3 | 0.95 |
| | 3 | | 1 | 2 | 1.54 |
| | | | 2 | 0 | ---- |
| | | | 3 | 0 | ---- |
| Macroinverte-brates | 1 | Turbidity | 1 | 10 | 0.24 |
| | | | 2 | 34 | 2.75 |
| | | | 3 | 33 | 3.31 |
| | 2 | | 1 | 5 | 0.91 |
| | | | 2 | 13 | 3.64 |
| | | | 3 | 5 | 2.06 |
| Aquatic Vege-tation | 1 | Turbidity | 1 | 12 | 0.20 |
| | | | 2 | 39 | 2.97 |
| | | | 3 | 35 | 3.33 |
| | 2 | | 1 | 2 | 1.54 |
| | | | 2 | 6 | 4.05 |
| | | | 3 | 2 | 0.00 |
| | 3 | | 1 | 1 | 1.44 |
| | | | 2 | 2 | 0.32 |
| | | | 3 | 1 | 3.12 |

TABLE XXXV (Continued)

| Characteristic - | Category | Characteristic - | Category | n | NWFL |
|---|---|---|---|---|---|
| Water Level | 1 | Turbidity | 1 | 7 | 0.35 |
| | | | 2 | 21 | 5.12 |
| | | | 3 | 28 | 4.16 |
| | 2 | | 1 | 6 | 0.24 |
| | | | 2 | 26 | 1.28 |
| | | | 3 | 10 | 0.33 |
| | 3 | | 1 | 2 | 1.54 |
| | | | 2 | 0 | ---- |
| | | | 3 | 0 | ---- |
| Aquatic Vegetation | 1 | Macroinvertebrates | 1 | 69 | 2.61 |
| | | | 2 | 17 | 3.20 |
| | 2 | | 1 | 6 | 4.05 |
| | | | 2 | 4 | 0.77 |
| | 3 | | 1 | 2 | 0.32 |
| | | | 2 | 2 | 2.28 |
| Water Level | 1 | Macroinvertebrates | 1 | 46 | 3.82 |
| | | | 2 | 10 | 5.06 |
| | 2 | | 1 | 30 | 0.99 |
| | | | 2 | 12 | 0.70 |
| | 3 | | 1 | 1 | 0.00 |
| | | | 2 | 1 | 3.09 |
| Water Level | 1 | Aquatic Vegetation | 1 | 54 | 4.18 |
| | | | 2 | 1 | 0.00 |
| | | | 3 | 1 | 0.30 |
| | 2 | | 1 | 31 | 0.28 |
| | | | 2 | 8 | 3.04 |
| | | | 3 | 3 | 1.64 |
| | 3 | | 1 | 1 | 0.00 |
| | | | 2 | 1 | 3.09 |
| | | | 3 | 0 | ---- |

TABLE XXXV (Continued)

| Analysis of Variance | | | | | |
|---|---|---|---|---|---|
| Source | df | Sum of Squares | Mean Square | F(cal) | Significance Level |
| Corrected Total | 99 | 8298.21 | 83.82 | | |
| Water Level | 2 | 238.53 | 119.27 | 1.24 | NS |
| Aquatic Vegetation | 2 | 7.84 | 3.92 | < 0 | - |
| Macroinvertebrates | 1 | 0.021 | 0.021 | < 0 | - |
| Turbidity | 2 | 86.62 | 43.31 | < 0 | - |
| Alkalinity | 2 | 664.28 | 332.14 | 3.47 | .900 |
| Water Level x Aquatic Vegetation Interaction | 3 | 78.45 | 26.15 | 0 | - |
| Water Level x Macroinvertebrates Interaction | 2 | 18.04 | 9.02 | < 0 | - |
| Water Level x Turbidity Interaction | 2 | 43.17 | 21.59 | < 0 | - |
| Water Level x Alkalinity Interaction | 1 | 324.04 | 324.04 | 3.38 | .900 |
| Aquatic Vegetation x Macroinvertebrates Interaction | 2 | 34.40 | 17.20 | < 0 | - |
| Aquatic Vegetation x Turbidity Interaction | 4 | 38.26 | 9.57 | < 0 | - |
| Aquatic Vegetation x Alkalinity Interaction | 2 | 26.88 | 13.44 | < 0 | - |
| Macroinvertebrate x Turbidity Interaction | 2 | 15.73 | 7.86 | < 0 | - |
| Macroinvertebrate x Alkalinity Interaction | 1 | 25.50 | 25.50 | < 0 | - |
| Turbidity x Alkalinity Interaction | 2 | 86.17 | 43.09 | < 0 | - |
| Residual | 69 | 6610.28 | 95.80 | | |

TABLE XXXVI

SPRING SEASONAL MEANS AND AOV FOR EFFECT DUE TO DYNAMIC HABITAT CHARACTERISTICS

Overall Means

| Characteristic | Category | n | NWFL |
|---|---|---|---|
| Turbidity | 1 (Clear) | 18 | 2.91 |
| | 2 (Intermediate) | 47 | 3.82 |
| | 3 (Turbid) | 35 | 3.97 |
| Alkalinity | 1 (< 50 ppm) | 30 | 1.52 |
| | 2 (50 - 150 ppm) | 61 | 4.63 |
| | 3 (> 150 ppm) | 9 | 10.95 |
| Aquatic Vegetation | 1 (High, > 10.0) | 77 | 4.57 |
| | 2 (Moderate, 1.0 - 10.0) | 18 | 0.73 |
| | 3 (Low, < 1.0) | 5 | 1.22 |
| Macroin-vertebrates | 1 (Low, < 500 Macroforms) | 46 | 2.36 |
| | 2 (High, > 500 Macroforms) | 54 | 4.86 |
| Water Level | 1 (Below Normal) | 79 | 4.45 |
| | 2 (Normal) | 21 | 0.92 |
| | 3 (Above Normal) | 0 | ---- |

Characteristic x Characteristic Means

| Characteristic | Category | Characteristic | Category | n | NWFL |
|---|---|---|---|---|---|
| Turbidity | 1 | Alkalinity | 1 | 7 | 0.09 |
| | | | 2 | 11 | 4.71 |
| | | | 3 | 6 | 5.95 |
| | 2 | | 1 | 12 | 0.38 |
| | | | 2 | 33 | 4.04 |
| | | | 3 | 2 | 8.95 |
| | 3 | | 1 | 11 | 2.65 |
| | | | 2 | 17 | 5.96 |
| | | | 3 | 1 | 0.85 |
| Macroinverte-brates | 1 | Alkalinity | 1 | 14 | 0.59 |
| | | | 2 | 32 | 3.61 |
| | | | 3 | 0 | ---- |

TABLE XXXVI (Continued)

| Characteristic - Category | | Characteristic - Category | | n | NWFL |
|---|---|---|---|---|---|
| Macroinvertebrates | 2 | Alkalinity | 1 | 16 | 2.37 |
| | | | 2 | 31 | 5.52 |
| | | | 3 | 9 | 12.95 |
| Aquatic Vegetation | 1 | Alkalinity | 1 | 24 | 1.64 |
| | | | 2 | 41 | 6.21 |
| | | | 3 | 6 | 8.90 |
| | 2 | | 1 | 4 | 0.15 |
| | | | 2 | 14 | 0.89 |
| | | | 3 | 3 | 1.21 |
| | 3 | | 1 | 2 | 2.29 |
| | | | 2 | 6 | 0.51 |
| | | | 3 | 0 | ---- |
| Water Level | 1 | Alkalinity | 1 | 20 | 1.73 |
| | | | 2 | 47 | 5.50 |
| | | | 3 | 9 | 8.80 |
| | 2 | | 1 | 10 | 0.90 |
| | | | 2 | 14 | 0.93 |
| | | | 3 | 0 | ---- |
| Macroinvertebrates | 1 | Turbidity | 1 | 6 | 2.05 |
| | | | 2 | 18 | 3.86 |
| | | | 3 | 22 | 1.22 |
| | 2 | | 1 | 12 | 3.34 |
| | | | 2 | 29 | 3.79 |
| | | | 3 | 13 | 8.64 |
| Aquatic Vegetation | 1 | Turbidity | 1 | 11 | 4.24 |
| | | | 2 | 36 | 4.81 |
| | | | 3 | 30 | 4.40 |
| | 2 | | 1 | 6 | 0.80 |
| | | | 2 | 8 | 0.70 |
| | | | 3 | 4 | 0.67 |
| | 3 | | 1 | 1 | 0.93 |
| | | | 2 | 3 | 0.23 |
| | | | 3 | 1 | 4.50 |
| Water Level | 1 | Turbidity | 1 | 11 | 4.68 |
| | | | 2 | 38 | 4.42 |
| | | | 3 | 30 | 4.40 |

TABLE XXXVI (Continued)

| | | | | | |
|---|---|---|---|---|---|
| Water Level | 2 | Turbidity | 1 | 7 | 0.13 |
| | | | 2 | 9 | 1.26 |
| | | | 3 | 5 | 1.41 |
| | 3 | | 1 | 0 | ---- |
| | | | 2 | 0 | ---- |
| | | | 3 | 0 | ---- |
| Aquatic Vegetation | 1 | Macroinvertebrates | 1 | 36 | 2.76 |
| | | | 2 | 41 | 6.15 |
| | 2 | | 1 | 9 | 1.00 |
| | | | 2 | 9 | 0.46 |
| | 3 | | 1 | 1 | 0.08 |
| | | | 2 | 4 | 1.51 |
| Water Level | 1 | Macroinvertebrates | 1 | 39 | 2.71 |
| | | | 2 | 40 | 6.15 |
| | 2 | | 1 | 7 | 0.40 |
| | | | 2 | 14 | 1.18 |
| | 3 | | 1 | 0 | ---- |
| | | | 2 | 0 | ---- |
| Water Level | 1 | Aquatic Vegetation | 1 | 65 | 5.24 |
| | | | 2 | 11 | 0.96 |
| | | | 3 | 3 | 0.23 |
| | 2 | | 1 | 12 | 0.95 |
| | | | 2 | 7 | 0.36 |
| | | | 3 | 2 | 2.71 |
| | 3 | | 1 | 0 | ---- |
| | | | 2 | 0 | ---- |
| | | | 3 | 0 | ---- |

TABLE XXXIV (Continued)

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | F(cal) | Significance |
|---|---|---|---|---|---|
| Corrected Total | 99 | 9767.31 | 98.66 | | |
| Water Level | 1 | 206.75 | 206.75 | 1.87 | .750 |
| Aquatic Vegetation | 2 | 247.53 | 123.76 | 1.12 | NS |
| Macroinvertebrates | 1 | 155.14 | 155.14 | 1.41 | .750 |
| Turbidity | 2 | 14.47 | 7.24 | $<0$ | - |
| Alkalinity | 2 | 940.32 | 470.16 | 4.26 | .900 |
| Water Level x Aquatic Vegetation Interaction | 2 | -11.43 | -5.71 | $<0$ | - |
| Water Level x Macroinvertebrates Interaction | 1 | 80.62 | 80.62 | $<0$ | - |
| Water Level x Turbidity Interaction | 2 | -7.21 | -3.61 | $<0$ | - |
| Water Level x Alkalinity Interaction | 1 | -18.98 | -18.98 | $<0$ | - |
| Aquatic Vegetation x Macroinvertebrates Interaction | 2 | 67.86 | 33.93 | $<0$ | - |
| Aquatic Vegetation x Turbidity Interaction | 4 | 3.50 | 0.87 | $<0$ | - |
| Aquatic Vegetation x Alkalinity Interaction | 2 | 75.25 | 37.62 | $<0$ | - |
| Macroinvertebrates x Turbidity Interaction | 2 | 301.80 | 150.90 | 1.37 | NS |
| Macroinvertebrates x Alkalinity Interaction | 1 | -82.38 | -82.38 | $<0$ | - |
| Turbidity x Alkalinity Interaction | 2 | 55.39 | 27.70 | $<0$ | - |
| Residual | 72 | 7944.38 | 110.34 | | |

# APPENDIX E

# ANALYSIS OF VARIANCE TABLES
# FOR WEATHER INFLUENCES

TABLE XXXVII

MEAN NUMBER OF WATERFOWL OBSERVED AND AOV FOR EFFECT DUE TO THE GENERAL WEATHER SITUATION

Seasonal Means

| Season | Weather Level | Mean Number of Waterfowl Observed |
|---|---|---|
| Fall | 1 (Static) | 53 |
| | 2 (Changing) | 72 |
| | 3 (Clearing) | 28 |
| Winter | 1 | 101 |
| | 2 | 94 |
| | 3 | 91 |
| Spring | 1 | 48 |
| | 2 | 23 |
| | 3 | 51 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Squares | Newman-Keuls "D" | Significance Ranking |
|---|---|---|---|---|---|
| Corrected Total | 1 | 34969.00 | 34969.00 | | |
| Season | 2 | 5060.67 | 2530.33 | 25.63 | W>F>S |
| General Weather | 2 | 172.67 | 86.33 | 58.44 | NS |
| Residual | 4 | 1326.67 | 331.67 | | |

TABLE XXXVIII

MEAN NUMBER OF WATERFOWL OBSERVED AND AOV
FOR EFFECT DUE TO VISIBILITY

Seasonal Means

| Season | Weather Level | Mean Number of Waterfowl Observed |
|---|---|---|
| Fall | 1 (Below Normal) | 113 |
| | 2 (Normal) | 48 |
| | 3 (Above Normal) | 0 |
| Winter | 1 | 99 |
| | 2 | 94 |
| | 3 | 0 |
| Spring | 1 | 50 |
| | 2 | 45 |
| | 3 | 0 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | Newman-Keuls "D" | Significance Ranking |
|---|---|---|---|---|---|
| Corrected Total | 1 | 33600.17 | 33600.17 | | |
| Season | 2 | 2497.33 | 1248.67 | 88.13 | W>F>S |
| Visibility | 1 | 937.50 | 937.50 | 102.90 | NS |
| Residual | 2 | 1200.00 | 600.00 | | |

TABLE XXXIX

MEAN NUMBER OF WATERFOWL OBSERVED AND AOV FOR EFFECT DUE TO AIR TEMPERATURE

Seasonal Means

| Season | Weather Level | Mean Number of Waterfowl Observed |
|---|---|---|
| Fall | 1 (Cold, < 0°) | 0 |
| | 2 (Cool, 0-10°) | 45 |
| | 3 (Warm, 10-27°) | 63 |
| | 4 (Hot, > 27°) | 19 |
| Winter | 1 | 78 |
| | 2 | 113 |
| | 3 | 76 |
| | 4 | 0 |
| Spring | 1 | 48 |
| | 2 | 61 |
| | 3 | 46 |
| | 4 | 37 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | Newman-Keuls "D" | Significance Ranking |
|---|---|---|---|---|---|
| Corrected Total | 1 | 28616.33 | 28616.33 | | |
| Season | 2 | 2454.17 | 1227.08 | 39.00 | W>F>S |
| Air Temperature | 3 | 5116.33 | 1705.44 | 33.73 | Cool > Warm, Cold, Hot |
| Residual | 6 | 4307.17 | 717.86 | | |

TABLE XL

MEAN NUMBER OF WATERFOWL OBSERVED AND AOV FOR EFFECT DUE TO WIND DIRECTION

Seasonal Means

| Season | Weather Level | Mean Number of Waterfowl Observed |
|---|---|---|
| Fall | 1 (North) | 41 |
| | 2 (East) | 26 |
| | 3 (South) | 60 |
| | 4 (West) | 9 |
| Winter | 1 | 77 |
| | 2 | 41 |
| | 3 | 117 |
| | 4 | 416 |
| Spring | 1 | 68 |
| | 2 | 27 |
| | 3 | 41 |
| | 4 | 0 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | Newman-Keuls "D" | Significance Ranking |
|---|---|---|---|---|---|
| Corrected Total | 1 | 70994.08 | 70994.08 | | |
| Season | 2 | 5060.67 | 2530.33 | 96.33 | W>F>S |
| Wind Direction | 3 | 19532.92 | 6510.97 | 85.98 | West > South, North, East |
| Residual | 6 | 72695.83 | 12115.97 | | |

TABLE XLI

MEAN NUMBER OF WATERFOWL OBSERVED AND AOV FOR EFFECT DUE TO AVERAGE WIND SPEED

Seasonal Means

| Season | Weather Level | Mean Number of Waterfowl Observed |
|---|---|---|
| Fall | 1 (0 - 16 kph) | 65 |
| | 2 (16 - 32 kph) | 16 |
| | 3 (32 - 48 kph) | 95 |
| | 4 (> 48 kph) | 0 |
| Winter | 1 | 98 |
| | 2 | 146 |
| | 3 | 57 |
| | 4 | 0 |
| Spring | 1 | 39 |
| | 2 | 51 |
| | 3 | 44 |
| | 4 | 40 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | Newman-Keuls "D" | Significance Ranking |
|---|---|---|---|---|---|
| Corrected Total | 1 | 35316.75 | 35316.75 | | |
| Season | 2 | 2646.50 | 1323.25 | 49.34 | W>F>S |
| Wind Speed | 3 | 6746.25 | 2248.75 | 44.33 | 16-32 kph> 0-16kkph, 32-48 kph and over 48 kph |
| Residual | 6 | 10623.50 | 1770.58 | | |

TABLE XLII

MEAN NUMBER OF WATERFOWL OBSERVED AND AOV FOR EFFECT DUE TO WIND CHILL INDEX

Seasonal Means

| Season | Weather Level | Mean Number of Waterfowl Observed |
|---|---|---|
| Fall | 1 (> 0°) | 52 |
| | 2 (-0° to -12°C) | 0 |
| | 3 (-12 to -23°C) | 0 |
| | 4 (< -23°C) | 0 |
| Winter | 1 | 97 |
| | 2 | 156 |
| | 3 | 63 |
| | 4 | 24 |
| Spring | 1 | 46 |
| | 2 | 35 |
| | 3 | 0 |
| | 4 | 0 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | Newman-Keuls "D" | Significance Ranking |
|---|---|---|---|---|---|
| Corrected Total | 1 | 18644.08 | 18644.08 | | |
| Season | 2 | 12572.17 | 6286.08 | 44.85 | W>F>S |
| Wind Chill Index | 3 | 7706.25 | 2568.75 | 46.55 | over 0° C> 0 to -12° C, -12 to -23° C and less than -23° C |
| Residual | 6 | 5412.50 | 902.08 | | |

TABLE XLIII

MEAN NUMBER OF WATERFOWL OBSERVED AND AOV FOR EFFECT DUE TO PERCENT OF CLOUD COVER

Seasonal Means

| Season | Weather Level | Mean Number of Waterfowl Observed |
|---|---|---|
| Fall | 1 (0 - 25%) | 47 |
| | 2 (25 - 50%) | 85 |
| | 3 (50 - 75%) | 48 |
| | 4 (75 - 100%) | 54 |
| Winter | 1 | 116 |
| | 2 | 67 |
| | 3 | 121 |
| | 4 | 85 |
| Spring | 1 | 43 |
| | 2 | 17 |
| | 3 | 95 |
| | 4 | 27 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Square | Newman-Keuls "D" | Significance Ranking |
|---|---|---|---|---|---|
| Corrected Total | 1 | 54002.08 | 54002.08 | | |
| Season | 2 | 5798.17 | 2899,08 | 32.18 | W>F>S |
| Precent Cloud Cover | 3 | 2080.92 | 693.64 | 43.07 | NS |
| Residual | 6 | 4475.83 | 745.97 | | |

TABLE XLIV

MEAN NUMBER OF WATERFOWL OBSERVED AND AOV FOR EFFECT DUE TO CURRENT PRECIPITATION

Seasonal Means

| Season | Weather Level | Mean Number of Waterfowl Observed |
|---|---|---|
| Fall | 1 (None) | 51 |
| | 2 (Light Rain) | 58 |
| | 3 (Heavy Rain) | 0 |
| | 4 (Snow/Sleet) | 0 |
| Winter | 1 | 106 |
| | 2 | 65 |
| | 3 | 0 |
| | 4 | 81 |
| Spring | 1 | 47 |
| | 2 | 26 |
| | 3 | 0 |
| | 4 | 0 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Squares | Newman-Keuls "D" | Significance Ranking |
|---|---|---|---|---|---|
| Corrected Total | 1 | 15696.33 | 15696.33 | | |
| Season | 2 | 4482.17 | 2241.08 | 41.15 | W>F>S |
| Current Precip. | 3 | 7763.00 | 2587.67 | 28.34 | No Precip.> Light Rain, Snow/Sleet, Heavy Rain |
| Residual | 6 | 2930.50 | 488.42 | | |

TABLE XLV

MEAN NUMBER OF WATERFOWL OBSERVED AND AOV FOR EFFECT DUE TO PAST PRECIPITATION

Seasonal Means

| Season | Weather Level | Mean Number of Waterfowl Observed |
|---|---|---|
| Fall | 1 (None in 48 hrs) | 50 |
| | 2 (< 5 cm in 48 hrs) | 55 |
| | 3 (> 5 cm in 48 hrs) | 0 |
| Winter | 1 | 74 |
| | 2 | 121 |
| | 3 | 339 |
| Spring | 1 | 49 |
| | 2 | 35 |
| | 3 | 0 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Squares | Newman-Keuls "D" | Significance Ranking |
|---|---|---|---|---|---|
| Corrected Total | 1 | 58081.00 | 58081.00 | | |
| Season | 2 | 42998.00 | 21499.00 | 115.31 | W>F>S |
| Past Precipitation | 2 | 5042.67 | 2521.33 | 140.31 | NS |
| Residual | 4 | 38067.33 | 9516.83 | | |

TABLE XLVI

MEAN NUMBER OF WATERFOWL OBSERVED AND AOV FOR EFFECT DUE TO BAROMETRIC PRESSURE

Seasonal Means

| Season | Weather Level | Mean Number of Waterfowl Observed |
|---|---|---|
| Fall | 1 (Steady) | 10 |
| | 2 (Rising) | 71 |
| | 3 (Falling) | 39 |
| Winter | 1 | 99 |
| | 2 | 67 |
| | 3 | 117 |
| Spring | 1 | 75 |
| | 2 | 54 |
| | 3 | 39 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Squares | Newman-Keuls "D" | Significance Ranking |
|---|---|---|---|---|---|
| Corrected Total | 1 | 36226.78 | 36226.78 | | |
| Season | 2 | 4677.56 | 2338.78 | 45.94 | W>F>S |
| Barometric Pressure | 2 | 21.56 | 10.78 | 57.50 | NS |
| Residual | 4 | 3777.11 | 944.28 | | |

TABLE XLVII

MEAN NUMBER OF WATERFOWL OBSERVED AND AOV FOR EFFECT DUE TO DISTANCE BEHIND A MAJOR FRONT

Seasonal Means

| Season | Weather Level | Mean Number of Waterfowl Observed |
|---|---|---|
| Fall | 1 (> 1600 km) | 0 |
| | 2 (1600-800 km) | 15 |
| | 3 (800-400 km) | 52 |
| | 4 (400-160 km) | 49 |
| | 5 (< 160 km) | 35 |
| | 6 (No Front) | 58 |
| Winter | 1 | 0 |
| | 2 | 197 |
| | 3 | 69 |
| | 4 | 81 |
| | 5 | 33 |
| | 6 | 105 |
| Spring | 1 | 0 |
| | 2 | 89 |
| | 3 | 109 |
| | 4 | 88 |
| | 5 | 31 |
| | 6 | 40 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Squares | Newman-Keuls "D" | Significance Ranking |
|---|---|---|---|---|---|
| Corrected Total | 1 | 61366.72 | 61366.72 | | |
| Season | 2 | 6359.11 | 3179.56 | 43.68 | W>F>S |
| Distance Behind Front | 5 | 19311.61 | 3862.32 | 25.27 | 1600-800 km> 800-400 km > 400-100 km, No Front, less than 160 km, Over 1600 km |
| Residual | 10 | 15233.56 | 1523.36 | | |

TABLE XLVIII

MEAN NUMBER OF WATERFOWL OBSERVED AND AOV FOR EFFECT DUE TO DISTANCE AHEAD OF A MAJOR FRONT

Seasonal Means

| Season | Weather Level | Mean Number of Waterfowl Observed |
|---|---|---|
| Fall | 1 (> 1600 km) | 32 |
| | 2 (1600-800 km) | 101 |
| | 3 (800-400 km) | 14 |
| | 4 (400-160 km) | 70 |
| | 5 (< 160 km) | 74 |
| | 6 (No Front) | 41 |
| Winter | 1 | 104 |
| | 2 | 72 |
| | 3 | 144 |
| | 4 | 98 |
| | 5 | 66 |
| | 6 | 91 |
| Spring | 1 | 8 |
| | 2 | 55 |
| | 3 | 65 |
| | 4 | 16 |
| | 5 | 37 |
| | 6 | 59 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Squares | Newman-Keuls "D" | Significance Ranking |
|---|---|---|---|---|---|
| Corrected Total | 1 | 73089.39 | 73089.39 | | |
| Season | 2 | 9985.44 | 4992.72 | 24.48 | W>F>S |
| Distance Ahead of Front | 5 | 1615.61 | 323.12 | 31.75 | NS |
| Residual | 10 | 10184.56 | 1018.46 | | |

TABLE XLIX

MEAN NUMBER OF WATERFOWL OBSERVED AND AOV FOR EFFECT DUE TO AMOUNT OF ICE COVER

Seasonal Means

| Season | Weather Level | Mean Number of Waterfowl Observed |
|---|---|---|
| Fall | 1 (None) | 52 |
| | 2 (< 50%) | 0 |
| | 3 (> 50%) | 0 |
| Winter | 1 | 95 |
| | 2 | 179 |
| | 3 | 19 |
| Spring | 1 | 45 |
| | 2 | 0 |
| | 3 | 0 |

Analysis of Variance

| Source | df | Sum of Squares | Mean Squares | Newman-Keuls "D" | Significance Ranking |
|---|---|---|---|---|---|
| Corrected Total | 1 | 16900.00 | 16900.00 | | |
| Season | 2 | 13292.67 | 6646.33 | 80.31 | W>F>S |
| Ice Cover | 2 | 6188.67 | 3094.33 | 77.50 | NS |
| Residual | 4 | 4774.67 | 2443.67 | | |

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